



TETRA TECH EC, INC.

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Task Order 98500-03-Y033

U.S. Fish and Wildlife Service
Bloomington Field Office
Attn: Mr. Dan Sparks
620 South Walker Street
Bloomington, Indiana 47403

Subject: Technical Memorandum: Development of Remedial Action Objectives to Support the Evaluation of Restoration Alternatives for the WBGCR

Dear Mr. Sparks:

We are pleased to submit the final revised Technical Memorandum entitled "Development of Remedial Action Objectives to Support the Evaluation of Restoration Alternatives" for the West Branch of the Grand Calumet River, Lake County, Indiana. The Technical Memorandum was previously entitled "Draft Technical Memorandum - Preliminary Problem Formulation" dated January 13, 2004 and was released to the public. After receiving comments from the Grand Calumet River Restoration Fund Council and the public, the Technical Memorandum was significantly revised. The responsiveness summary to the public comments is included in Appendix C.

If you have any questions, feel free to call me at (425) 482-7840 or alternatively Jennifer Hawkins at (425) 482-7678.

Sincerely,
TETRA TECH EC

Gary Braun
Project Manager

Attachment

Distribution:
Jim Smith – IDEM
Patrick Peine-USFWS Region 3,CO (w/o attachment)
Mark Griswold – TtEC Denver
Don MacDonald – MESL
FWS3DCC /Chron



12100 Northeast 195th Street, Suite 200, Bothell, WA 98011
Tel 425.482.7600 Fax 425.482.7652
www.ttfwi.com

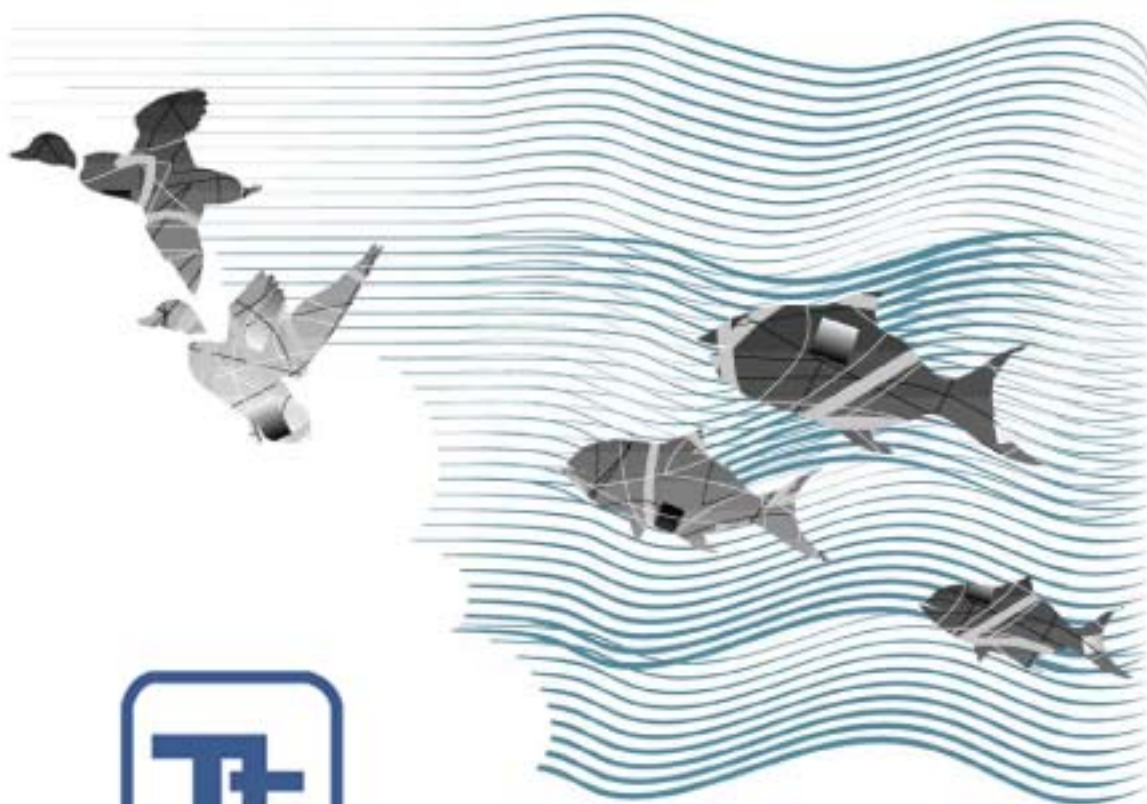


U.S. Fish and Wildlife Service

Technical Memorandum

Development of Remedial Action Objectives to Support the Evaluation of Restoration Alternatives

West Branch of the Grand Calumet River, Indiana



TETRA TECH EC, INC.

WEST BRANCH
OF THE GRAND CALUMET RIVER
LAKE COUNTY, INDIANA

TECHNICAL MEMORANDUM

**DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES TO
SUPPORT THE EVALUATION OF RESTORATION
ALTERNATIVES FOR THE WEST BRANCH OF THE GRAND
CALUMET RIVER, INDIANA**

September 2005

Prepared by



TETRA TECH EC, INC.

12100 NE 195th Street
Bothell, Washington 98011
(425) 482-7600
(425) 482-7652 (Fax)

Prepared for

U.S. Fish & Wildlife Service
Bloomington Field Office
620 South Walker Street
Bloomington, Indiana 47403

Under Contract to

U.S. Fish & Wildlife Service
Environmental and Facility Compliance Branch
P.O. Box 25207
7333 W. Jefferson Avenue, Suite 375
Denver, Colorado 80225-0207

Contract No.: GS-10F-0208J
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ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
ARCS	Assessment and Remediation of Contaminated Sediments
BDL	below detection limit
Bgs	below ground surface
BHHRA	baseline human health risk assessment
BOD	biological oxygen demand
Cal EPA	California Environmental Protection
CalEPA	California EPA
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
COC	chemical of concern
COPC	chemical of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CSO	combined sewer overflow outfalls
CWA	Clean Water Act
DOI	U.S. Department of the Interior
DW	dry weight
EBGCR	East Branch of the Grand Calumet River
ECSD	East Chicago Sanitary District
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FWENC	Foster Wheeler Environmental Corporation (now known as Tetra Tech EC, Inc.)
GCR	Grand Calumet River
GCRRF	Grand Calumet River Restoration Fund
GIS	geographic information system
HEAST	Health Effects Assessment Summary Tables
HSD	Hammond Sanitary District
IDEM	Indiana Department of Environmental Management

IDNR	Indiana Department of Natural Resources
IEUBK	Integrated Exposure Uptake Biokinetic
IHAOC	Indiana Harbor Area of Concern
IHC	Indiana Harbor Canal
IJC	International Joint Commission
IOT	incidence of toxicity
IRIS	Integrated Risk Information System
MESL	MacDonald Environmental Services Limited
MGD	millions of gallons per day
MOT	magnitude of toxicity
MOU	memorandum of understanding
MRL	minimal risk level
MRL	Minimal Risk Level
NAPL	non-aqueous phase liquid
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
OC	organic carbon
OPA	Oil Pollution Act
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	probable effect concentration
PEQ	probable effect concentration
PPRTV	Provisional Peer Reviewed Toxicity Values
PRG	preliminary remediation goal
RAO	remedial action objective
RAP	remedial action plan
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
SVOC	semivolatile organic compound
TEC	threshold effect concentration
TMDL	total maximum daily load

TOC	total organic carbon
TtEC	Tetra Tech EC, Inc.
UCC	upper confidence limit
USFWS	U.S. Fish and Wildlife Service
WBGCR	West Branch of the Grand Calumet River
WWTP	wastewater treatment plant

ACKNOWLEDGEMENTS

This document was compiled by Tetra Tech EC, Inc. (TtEC), formerly known as Foster Wheeler Environmental Corporation (FWENC), under contract with the U.S. Fish & Wildlife Service (USFWS) in accordance with the requirements of the Scope of Work (SOW) for Task Order 98500-03-Y033 of Contract GS-10F-0208J, dated October 1, 2003. This project was funded by The Grand Calumet River Restoration Fund (GCRRF) Council. Mr. Dan Sparks was the USFWS project manager; Dr. Jim Smith was the Indiana Department of Environmental Management (IDEM) council representative; Mr. Michael Mikulka was the U.S. Environmental Protection Agency, Region 5, council representative; Dr. Wayne C. Faatz was the Indiana Department of Natural Resources council representative; and Mr. Gary Braun was the TtEC project manager. The overall program manager for Tetra Tech EC was Mark Griswold.

The primary authors of this report were Mr. Gary Braun of TtEC and Mr. Don MacDonald of MacDonald Environmental Services Limited (MESL).

ABSTRACT

This report is the first in a series of documents that were prepared to support the development and evaluation of restoration alternatives for the West Branch of the Grand Calumet River (WBGCR). More specifically, this document provides an overview of the impacts on human health and the environment associated with exposure to contaminated water, sediment, and biota in the WBGCR. The process that was used to develop and evaluate restoration alternatives for the WBGCR, is also described. Finally, the remedial action objectives (RAOs) that were developed to support the restoration alternatives selection process are presented. Subsequent documents in the series present: 1) the results of the assessment that was conducted to assess risks to human health associated with exposure to surface water, sediment, and fish in the WBGCR under baseline conditions; 2) the risk-based preliminary remediation goals (PRGs) for ecological receptors in the WBGCR; and 3) candidate restoration alternatives that were developed to address risks to human health and ecological receptors, as well as the results of restoration alternatives analysis. Collectively, these work plan products are intended to provide the Grand Calumet River Restoration Fund (GCRRF) Council and the public with the information needed to select restoration alternatives that effectively address and correct environmental contamination in the WBGCR.

1. INTRODUCTION

1.1 BACKGROUND

The Grand Calumet River (GCR) is located in Lake County in northwestern Indiana (Figure 1). The river's watershed is relatively flat and comprises approximately 22 square miles of northern Indiana. The GCR comprises two east-west oriented branches that meet at the southern end of the Indiana Harbor Ship Canal (IHC). The East Branch of the Grand Calumet River (EBGCR) originates at the Grand Calumet River Lagoons, just east of the United States Steel Gary Works facility. The EBGCR flows west from this point for approximately 10 miles to its confluence with the IHC. The West Branch of the Grand Calumet River (WBGCR) usually flows both east (i.e., to IHC) and west (i.e., to its confluence with the Little Calumet River), with a hydraulic divide typically present in the vicinity of the Hammond Sanitary District outfall just east of Columbia Avenue.

There has been a long history of industrial activities within the GCR basin, with the land located north of the river being one of the most heavily industrialized areas in the United States (Natural Resources Trustees 1997; Bright 1988; Brannon et al. 1989; Ryder 1993). Some of the industries that operate, or have operated, in the area include steel mills, foundries, chemical plants, packing plants, a distillery, a concrete/cement fabricator, oil refineries, and milling and machining companies (Ryder 1993). Permitted discharges from industrial operations, municipal wastewater treatment plants (WWTPs), and other sources contribute substantial quantities of wastewater to the river system. Nonpoint sources of contaminants to the system include urban and industrial runoff, combined sewer overflows (CSOs), leachate or overflow from a number of wastefills or ponds, and spills of pollutants in and around industrial operations (Brannon et al. 1989). The Indiana Department of Environmental Management (IDEM 1991) compiled information on potential contaminant sources within the Indiana Harbor Area of Concern (IHAOC), which included:

- Eight major permitted industrial point-source dischargers [i.e., permitted under the National Pollutant Discharge Elimination System (NPDES)], including U.S. Steel, LTV Steel, ISPAT Inland Steel, PRAXAIR, CERESTA, BP Amoco, NIPSCO, and State Line Energy (IDEM 2004);
- Fifty-two properties listed in the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) as containing potentially uncontrolled hazardous wastes that require investigation;

- More than 400 facilities subject to regulation under the Resource Conservation and Recovery Act (RCRA), which means that they generate, transport, treat, store, or dispose of hazardous wastes; and,
- Three municipal WWTPs (i.e., that are operated by the Hammond, Gary, and East Chicago Sanitary Districts).

In total, it was estimated that the IHAOC also received more than 11 billion gallons/year of untreated stormwater via 12 CSOs (IDEM 1991). The locations of existing and historic outfalls within the IHAOC are shown in Figure 2. Releases of waste and wastewaters from these sources have resulted in the contamination of surface water, groundwater, sediment, and biota with a variety of toxic and bioaccumulative substances, including heavy metals, phenols, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, cyanide, and several other organic chemicals (Crane 1996; USGS 2000).

Concerns associated with the widespread contamination of surface waters and sediments led the International Joint Commission (IJC) to designate the Grand Calumet River-Indiana Harbor complex as an Area of Concern (IHAOC) under the Great Lakes Water Quality Agreement (IJC 1989). The Agreement directed that a Remedial Action Plan (RAP) be developed and implemented at each Area of Concern in order to restore the beneficial uses. In response to concerns regarding environmental contamination and associated impairment of beneficial uses in the IHAOC, the IDEM and its partners developed a Stage One RAP for the IHC, the GCR, and nearshore Lake Michigan and submitted it to the International Joint Commission in 1991 (IDEM 1991). A Stage 2 RAP was also developed and submitted to the IJC in 1997 (IDEM 1997).

1.2 STUDY AREA

Although natural resource damage assessment activities have been conducted throughout the IHAOC, only a portion of the Area of Concern is being addressed in the current study. More specifically, the study area is considered to include the portion of the WBGCR extending from Indianapolis Boulevard west to the Indiana/Illinois state line (hereafter referred to as the WBGCR; Figure 3). From a hydrological perspective, this portion of the WBGCR is complicated. The river usually flows in a westerly direction from Columbia Avenue to the confluence of the Little Calumet River. However, the river can flow in either an easterly or a westerly direction between Columbia Avenue and Indianapolis Boulevard, depending on the water level in Lake Michigan (USACE 1995). Most of the flow in the WBGCR is derived from wastewater discharges from the Hammond Sanitary District WWTP and the East Chicago WWTP; however, stormwater runoff and discharges from various CSOs also contribute significantly to the flow of the river during and following rain and snowmelt events.

Figure 1. Map of IHAOC showing the boundaries of the reaches of the assessment area (as designated by MacDonald and Ingersoll 2000).

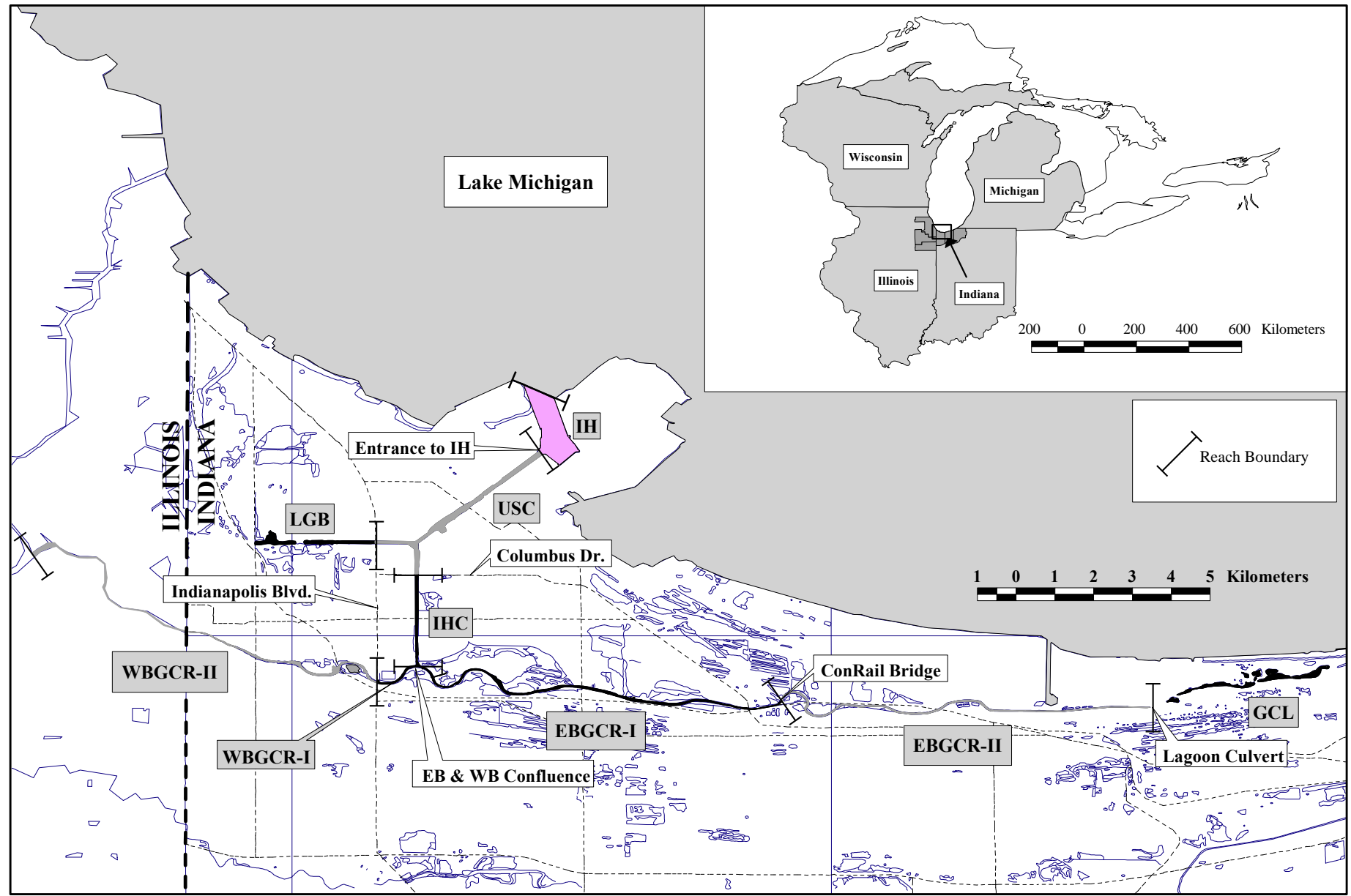


Figure 2. Map of the IHAOC showing the locations of discharges to receiving waters.

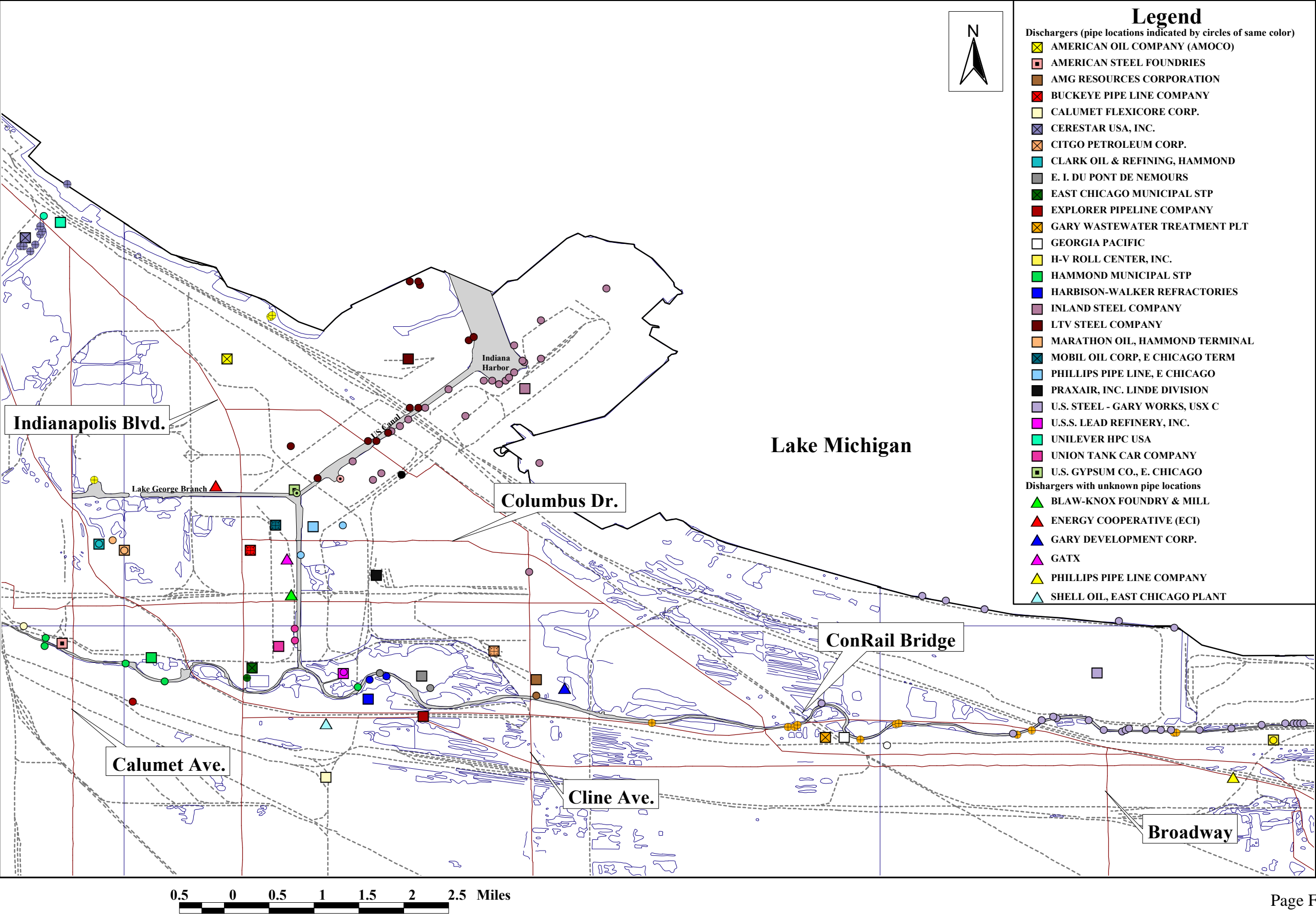
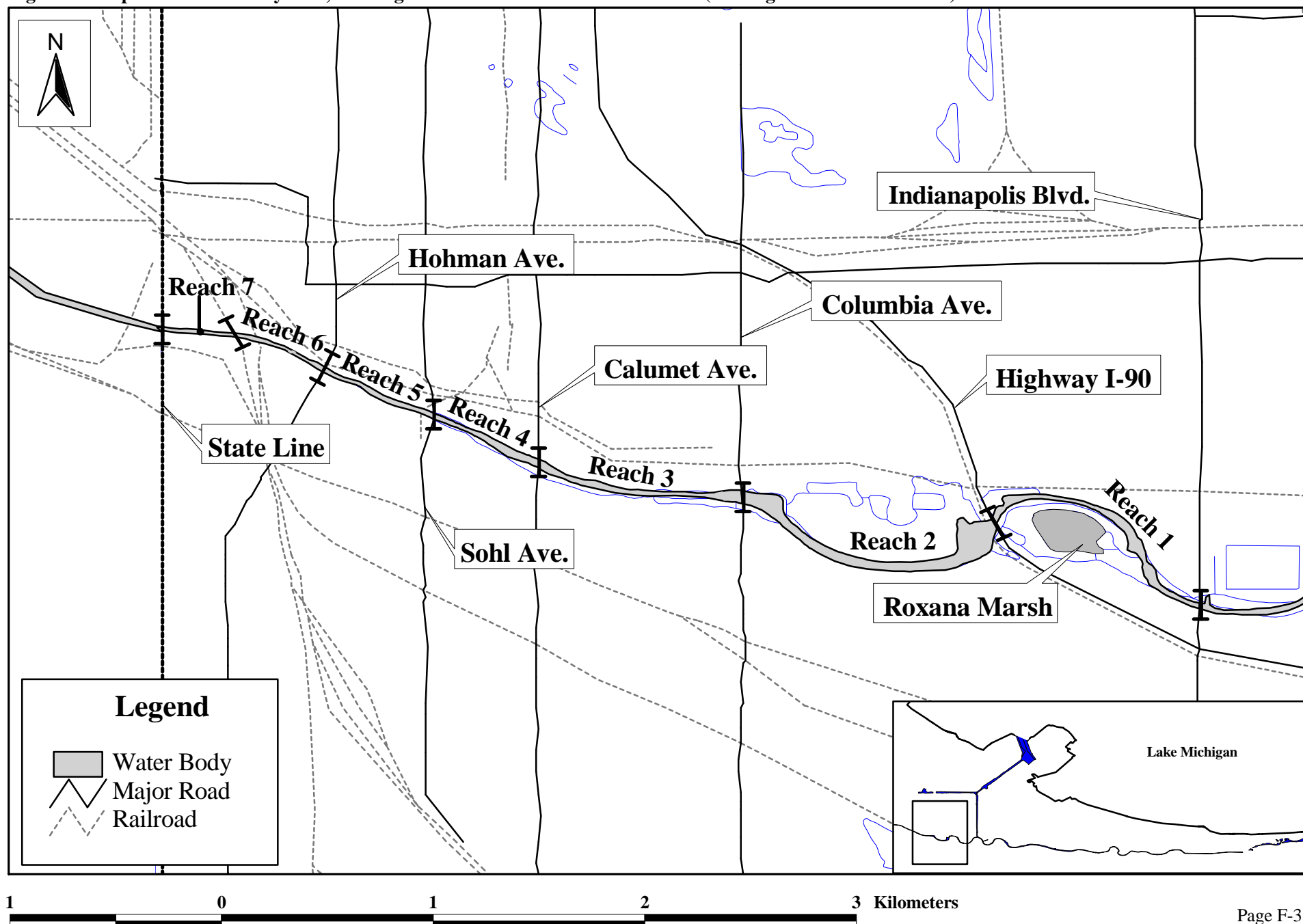


Figure 3. Map of WBGCR study area, showing the boundaries of the river reaches (as designated in FWEC 2003).



1.3 CONTAMINANT SOURCES IN THE WEST BRANCH OF THE GRAND CALUMET RIVER

The WBGCR has received inputs of environmental contaminants from several sources over the past century. The available information on known major and minor sources of environmental contaminants to the WBGCR include:

- The **East Chicago Sanitary District (ECSD)** WWTP, which is located on the north side of the West Branch, just east of Indianapolis Boulevard. The plant is an oxidation ditch facility with mixed media filtration designed for an average daily flow of 15.0 million gallons/day (MGD), and achieves advanced wastewater treatment with a low carbonaceous biological oxygen demand (BOD), low total suspended solids, and a highly nitrified effluent. Disinfection is accomplished by ultraviolet light.
- The ECSD also operates a flow-through **80-million-gallon lagoon for combined sewer overflow (CSO) storage and treatment** adjacent to the ECSD WWTP, north of the West Branch on the east side of Indianapolis Boulevard. Discharge of the settled effluent is to the ECSD discharge channel located just east of Indianapolis Boulevard. The ECSD operates a separate stormwater pumping station located on the south side of the West Branch in Reach 2.
- The **Sanitary District of Hammond (HSD)** WWTP, located on the north bank of the West Branch, east of Columbia Avenue. The plant is an activated sludge facility with mixed media filtration designed for an average daily flow of 48.0 MGD of high-strength industrial waste, and achieves advanced wastewater treatment with a low carbonaceous BOD, low total suspended solids and a highly nitrified, dechlorinated effluent. Peak monthly flows average 55.0 MGD in the spring.

HSD is required to construct a **detention basin** to store peak wet weather flows pursuant to the consent agreement between HSD, U.S. Environmental Protection Agency (EPA) and IDEM. The location of this basin is most likely on the north side of the West Branch, west of Columbia Avenue. A new outfall to the West Branch from this basin may have to be constructed in the event that peak flows exceed the combined treatment/storage capacity at the HSD.

HSD is required to close its **former sludge lagoons** located on the north bank of the West Branch, east of Columbia Avenue. All sludge from the lagoons has been removed by the HSD. The lagoons were previously known to be contributing high ammonia loads to the West Branch. Now that the sludge has been removed, the extent of residual contamination contribution to the WBGCR is unknown.

- HSD also maintains a number of CSOs (i.e., at Johnson Avenue, Sohl Avenue, and Columbia Avenue) that discharge stormwater and untreated wastewater to the river during runoff events (Ryder 1993; HNTB 1995; Bell 1995).

The Columbia Avenue CSO located on the north side of the West Branch, just east of Columbia Avenue, operated by the HSD. This CSO is a major source of high strength untreated wastewater during rain events and is a major cause of non-attainment in the West Branch. The existing consent agreement between HSD, EPA and IDEM requires that this CSO be eliminated by 2009.

The Johnson Avenue CSO located on the north side of the West Branch, just east of Johnson/Sohl Avenue, operated by the HSD. This CSO is a major source of high-strength untreated wastewater during rain events and is a major cause of nonattainment in the West Branch. The existing consent agreement between HSD, EPA and IDEM requires that this CSO be eliminated by 2009. HSD has advised EPA and IDEM that the possible route for the force main to phase out the CSO would be on the north side of the West Branch south of the City Baptist School.

The Sohl Avenue CSO located on the south side of the West Branch, just east of Sohl Avenue, operated by the HSD. This CSO is a major source of untreated wastewater during rain events and is a major cause of nonattainment in the West Branch. The existing consent agreement between HSD, EPA, and IDEM requires that this CSO be eliminated by 2009. HSD has advised EPA and IDEM that the possible route for the force main to phase out the CSO would be on the north side of the West Branch south of the City Baptist School.

The HSD has completed construction of a new separate stormwater outfall to the West Branch to facilitate its sewer separation of neighborhoods south of the West Branch with a storm drain installed along Howard Street. The outfall of this drain has been completed and enters the WBGCR at the end of Howard Street (1 block west of Columbia Avenue) in Reach 3.

- The NIPSCO/NiSource Manufactured Gas Plant (MGP) located on the south side of the West Branch, just west of Hohman Avenue. This MGP continues to be a source of constituents to the West Branch. A plan for voluntary remediation of the site by NIPSCO/NiSource has been submitted to IDEM for approval. The plan as presented would cut off the flow of constituents from the site to the West Branch.
- Contaminated sediment with coal tar characteristics within the West Branch from Hohman Avenue to the state line (Reaches 6 & 7). A plan for voluntary remediation of the West Branch Grand Calumet River from Hohman Avenue west to the extension of its

property line (east of the next railroad bridge) has been submitted by NIPSCO/NiSource to IDEM for approval. The plan involves partial excavation of contaminated material followed by capping.

- Contaminated groundwater in Reach 4 has been documented by EPA as part of a well installation and sampling effort in the spring of 2004. A report to partially delineate the extent of contamination is still under preparation.
- The American Steel Foundries WWTP discharge is located on the north side of the West Branch between Calumet and Sohl Avenues in Reach 5. This is a minor industrial discharger.
- The Flexicore Cement WWTP discharge is located on the north side of the West Branch west of Hohman Avenue in Reach 7. This is a minor industrial discharger that discharges treated sanitary wastewater.

Some of the substances that have been released include total organic carbon (TOC), nutrients, metals, oil and grease, phenolics, PAHs, phthalates, pesticides, and PCBs (Bright 1988; Polls et al. 1993; Hoke et al. 1993; Dorkin 1994; Ingersoll and MacDonald 1999).

In addition to these point-source discharges, there are a number of potential nonpoint sources of contaminants to the river (e.g., pipeline crossings, such as those maintained by BP/Amoco Pipeline, Buckeye/NORCO Pipeline, Westshore Pipeline, and Wolverine Pipeline; hazardous waste sites; etc.). Currently, there are 78 RCRA-listed sites located within 1 mile of the river channel; 10 of these sites are listed in the toxics release inventory, and spills have occurred at 10 of these sites.

A number of studies have been conducted to assess the nature, severity, and extent of contamination in the WBGCR (Ingersoll and MacDonald 1999; MacDonald and Ingersoll 2000; FWENC 2002b; 2003). The results of these investigations demonstrate that surface water, groundwater, sediment, and biological tissues in the WBGCR have been contaminated by a variety of toxic and bioaccumulative substances. Of particular concern relative to the evaluation of restoration alternatives, sediments throughout the WBGCR are highly contaminated with heavy metals, PAHs, chlorinated pesticides, and PCBs (Ingersoll and MacDonald 1999; MacDonald and Ingersoll 2000; MacDonald et al. 2002a, 2002b; FWENC 2002b, 2003). In addition, PCBs and various organochlorine pesticides have been detected in fish tissues from the WBGCR.

1.4 IMPACTS OF HAZARDOUS SUBSTANCES IN THE WEST BRANCH OF THE GRAND CALUMET RIVER

To address concerns relative to environmental contamination in the WBGCR, the natural resource trustees and others have conducted a variety of studies to assess the impacts of hazardous substances on human health and the environment. Overall, the results of these investigations demonstrate that the levels of certain bioaccumulative substances occur in fish tissues at levels sufficient to adversely affect human health (EPA 1994). As a result, fish consumption advisories have been issued for the Grand Calumet River and Indiana Harbor Canal virtually every year between 1986 and 2003 (MacDonald *et al.* 2003a). In addition, impacts on sediment-dwelling organisms, fish, and aquatic-dependent wildlife associated with exposure to contaminated environmental media were documented by Ingersoll and MacDonald (1999), MacDonald and Ingersoll (2000), and MacDonald *et al.* (2002a; 2002b). Therefore, it is apparent that water, sediment, and biological tissues in the WBGCR are sufficiently contaminated to adversely affect human health and ecological receptors. See Chapter 2 of this report for a more detailed description of the impacts that have been documented in the WBGCR in association with exposure to contaminated water, sediment, and biota.

1.5 APPROACH TO THE RESTORATION OF NATURAL RESOURCES IN THE WEST BRANCH OF THE GRAND CALUMET RIVER

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; commonly known as the federal Superfund law), the federal Water Pollution Control Act (commonly known as the Clean Water Act; CWA), and the Oil Pollution Act (OPA) authorize states, federally recognized tribes, and certain federal agencies to act as Trustees on behalf of the public and to bring claims against responsible parties for damages to restore, replace, or acquire natural resources equivalent to those harmed by the release of hazardous substances and oil. Accordingly, IDEM, Indiana Department of Natural Resources (IDNR), the U.S. Department of the Interior (DOI; represented by the U.S. Fish and Wildlife Service and the National Park Service; USFWS and NPS) worked with the EPA to determine what remedial actions are necessary to address natural resource injuries caused by past releases of oil and other hazardous substances into the IHAOC (IEc 2004). CERCLA, the CWA, and OPA require that any natural resource damages received—either through negotiated settlements or litigation with responsible parties—must be used to restore, replace, or acquire resources equivalent to injured natural resources (IEc 2004).

Following settlement with the Industrial Users of the Hammond Sanitary District in February, 1997, a Trust Agreement for the GCRRF was established by a Memorandum of Understanding (MOU) among EPA, USFWS, IDEM, and IDNR. The GCRRF Council, which consists of

representatives of each of these agencies, was established at that time. Payments to the GCRRF by settling parties were to address the effects of sediment contamination on human health and the environment. Specifically, the fund was established to address and correct environmental contamination in the Area of Concern, including the remediation of contaminated sediment and the restoration of natural resources damages in the vicinity of the WBGCR.

The GCRRF Council is formulating a plan for cleaning up contaminated sediments and restoring natural resources that will be guided by the results of the Restoration Alternatives Development and Evaluation project. This project involves three main phases, including: Phase 1—compilation of historical information on sediment contamination and identification of data gaps; Phase 2—further site characterization to fill the identified data gaps; and, Phase 3—development and evaluation of restoration alternatives.

1.6 PURPOSE AND SCOPE OF THIS REPORT

Tetra Tech EC, Inc. (TtEC) has been tasked with supporting the GCRRF Council in Phase 3 of the Restoration Alternatives Development and Evaluation project. This phase of the project, which is being conducted under USFWS GSA Contract GS-10F-0208J (Task Order 98500-03-Y033), is intended to provide the information needed by the GCRRF Council and the public to select one or more restoration alternatives that will address and correct sediment contamination in the WBGCR.

This report is the first in a series of documents that are being prepared to support the development and evaluation of restoration alternatives for the West Branch of the Grand Calumet River. More specifically, this document provides an overview of the impacts on human health and the environment that have been documented in the WBGCR in association with exposure to contaminated environmental media (Chapter 2). The process that was used to develop and evaluate restoration alternatives for the WBGCR is also described in this report (Chapter 3). Finally, the RAOs that were developed to support the restoration alternatives selection process for the WBGCR are presented (Chapter 4). Subsequent documents in the series present: 1) the results of the assessment that was conducted to evaluate risk to human health associated with exposure to surface water, sediment, and fish in the WBGCR under baseline conditions (TtEC 2005); 2) the risk-based PRGs for ecological receptors in the WBGCR; and, 3) candidate restoration alternatives that were developed to address risks to human health and ecological receptors, as well as the results of restoration alternatives analysis.

2. ASSESSMENT OF RISKS TO HUMAN HEALTH AND THE ENVIRONMENT IN THE WEST BRANCH OF THE GRAND CALUMET RIVER

Information from a number of sources indicates that the Grand Calumet River drainage basin is one of the most highly industrialized areas in the United States (Bright 1988; Brannon et al. 1989; Ryder 1993). Permitted discharges from industrial operations, municipal WWTPs, and other sources contribute substantial quantities of wastewater to the river system. Nonpoint sources of contaminants to the system include urban and industrial runoff, CSOs, leachate or overflow from a number of wastefills or ponds, and spills of pollutants in and around industrial operations (Brannon et al. 1989). Releases of waste and wastewaters from these sources have resulted in the contamination of surface water, groundwater, sediment, and biota with a variety of toxic and bioaccumulative substances, including heavy metals, phenols, PAHs, PCBs, pesticides, cyanide, and several other organic chemicals (Crane 1996; USGS 2000). Concerns associated with the widespread contamination of surface waters and sediments led to the IJC to designate the Grand Calumet River-Indiana Harbor complex as an Area of Concern under the Great Lakes Water Quality Agreement (IJC 1989).

To address concerns relative to the contamination of environmental media, the Natural Resources Trustees initiated a natural resource damage assessment of the IHAOC in 1997 (Natural Resources Trustees 1997). Although the WBGCR was not explicitly included in the assessment area, injuries to surface water and biological resources in both reaches of the WBGCR (i.e., WBGCR-I, from IHC to Indianapolis Boulevard, and WBGCR-II, from Indianapolis Boulevard to the state line) were evaluated as part of these investigations. In addition, a site-specific assessment of sediment injury in the WBGCR has been conducted. The following discussion summarizes the results of earlier studies that assessed the actual and potential impacts of environmental contamination in the WBGCR on human health and ecological receptors.

2.1 POTENTIAL IMPACTS OF ENVIRONMENTAL CONTAMINATION ON HUMAN HEALTH

Potential impacts to human health were evaluated by EPA's Great Lakes National Program Office in 1994 (EPA 1994). The WBGCR area was included within the IHAOC under the Assessment and Remediation of Contaminated Sediments (ARCS) Program. The human health risk assessment focused on three pathways by which residents of the IHAOC could be exposed to sediment-derived contaminants: 1) consumption of contaminated fish, 2) dermal exposure to

contaminated water at Roxana Marsh, and 3) dermal exposure to contaminated sediment at Roxana Marsh. Other exposure pathways were deemed either incomplete (e.g., ingestion of sediments) or insignificant (e.g., dermal exposure to surface water in the Indiana Harbor while fishing). The resulting reasonable maximum exposure (RME) risk estimates for exposure to surface water and sediments in Roxana Marsh were determined to be 6×10^{-7} and 4×10^{-6} , respectively. The corresponding hazard indices were 0.001 and 0.1, respectively. Risk estimates for fish consumption were calculated separately for various combinations of fish species and sampling locations. The RME risk estimates for fish collected from the Grand Calumet River ranged from 6×10^{-6} for whole pumpkinseed to 1×10^{-3} for whole carp. These levels exceed the point-of-departure risk level of 1×10^{-6} . The associated RME hazard indices were 0.01 for whole pumpkinseed and 0.4 for whole carp. Although the calculated hazard indices did not exceed the benchmark of 1, the calculated values did not include some of the chemicals detected due to an absence of non-cancer toxicity values.

The Great Lakes jurisdictions have issued consumption advisories for sport fish since the late 1960s and early 1970s. Stringent fish advisories have been issued for the GCR/IHC AOC. The 1990 fish advisory states that no fish should be eaten from the waters of the Grand Calumet River and Indiana Harbor Canal (EPA 1994). Despite these warnings, people have been observed fishing along portions of the GCR/IHC.

More recently, MacDonald et al. (2003a) conducted an assessment of injury to human uses of fisheries resources in the IHAOC. The results of this study showed that the levels of chemicals of potential concern (COPCs) in WBGCR sediments frequently exceeded the concentrations that have been established for the protection of human health (i.e., to protect against harmful levels of accumulation of COPCs in fish tissues). In addition, the concentrations of certain contaminants in fish tissues exceeded U.S. Food and Drug Administration action levels or Indiana State Department of Health Group 1 threshold levels. Furthermore, fish consumption advisories have been issued for the GCR and IHC virtually every year between 1986 and 2003. Accordingly, it was concluded that injury to human uses of fisheries resources had occurred within the IHAOC, including the WBGCR.

2.2 IMPACTS OF ENVIRONMENTAL CONTAMINATION ON ECOLOGICAL RECEPTORS

The sediments throughout the WBGCR are highly contaminated with heavy metals and various organic compounds, including semivolatile organic compounds (SVOCs), chlorinated pesticides, and PCBs (MacDonald et al. 2002a; 2002b). Although a baseline ecological risk assessment (BERA) has not been completed on the WBGCR, the results of several investigations

demonstrate that ecological receptors have been adversely affected by exposure to hazardous substances in the WBGCR.

In 1999, Ingersoll and MacDonald (1999) conducted an assessment of sediment injury in the WBGCR using data and information that had been collected between 1982 and 1994. The results of this investigation demonstrated that the concentrations of sediment-associated COPCs in the WBGCR were sufficient to injure sediment-dwelling organisms. In addition, the results of whole-sediment and pore-water toxicity tests confirmed that WBGCR sediments were harmful to benthic invertebrates and fish. Furthermore, the structure of benthic invertebrate communities were altered throughout the WBGCR, as evidenced by a shift toward pollution-tolerant species and a loss of preferred fish food organisms. Fish populations were also reduced in the WBGCR due to the loss or degradation of habitat associated with inputs of sewage sludge and other substances. Various metals (arsenic, cadmium, chromium, copper, nickel, and zinc), PAHs (naphthalene, phenanthrene, benz(a)anthracene, benzo(a)pyrene, chrysene, pyrene, and total PAHs), PCBs (total PCBs), pesticides (chlordane, dieldrin, sum DDE, total DDT, heptachlor, lindane, and toxaphene), phenols (phenol), and conventional indicators (dissolved oxygen, sediment oxygen demand, total organic carbon, and unionized ammonia) were identified as the substances that were causing or substantially contributing to sediment injury in the WBGCR (i.e., the contaminants of concern; COCs).

Subsequently, MacDonald and Ingersoll et al. (2000) and MacDonald et al. (2002a) conducted a broader assessment of sediment injury in the IHAOC, including the WBGCR from Indianapolis Boulevard to the Indiana/Illinois state line. The results of this follow-up investigation, which utilized data collected between 1970 and 2000, showed that the levels of COPCs (i.e., metals, PAHs, PCBs, unionized ammonia, and/or phenol) in whole sediment and pore water were sufficient to injure sediment-dwelling organisms. In addition, the results of toxicity tests confirmed that whole sediments, pore water, and/or elutriates were toxic to aquatic organisms. That benthic invertebrate communities were significantly altered relative to reference sites provided further confirmatory evidence that injury to sediments and sediment-dwelling organisms had occurred in this reach of the river (MacDonald et al. 2002a).

MacDonald and Ingersoll (2000) and MacDonald et al. (2002b) also assessed injury to fish and wildlife resources in the WBGCR. The results of this study demonstrated that contaminated sediments were adversely affecting fish and wildlife species in at least four ways. First, pore-water samples from the WBGCR were shown to be toxic to fish. Second, alteration of benthic invertebrate communities resulted in a reduction in the abundance of preferred fish food organisms. Third, fish populations inhabiting the WBGCR were found to be severely reduced, most likely as a result of habitat alteration and degradation. Finally, the concentrations of sediment-associated contaminants frequently exceeded the levels that have been established to

protect piscivorous wildlife species (e.g., herons, kingfishers, and mink; MacDonald et al. 2002b). Therefore, it was concluded that contaminated sediments were adversely affecting fish and wildlife resources utilizing habitats in the WBGCR.

Following the completion of the sediment injury assessments, the site was further characterized to determine the nature, magnitude, and spatial extent of contamination and associated effects on sediment-dwelling organisms (FWENC 2002b, 2003; Kemble et al. 2002, 2003). The results of these follow-up investigations showed that metals, PAHs, and/or PCBs were present at elevated levels (i.e., above probable effect concentrations; PECs) in each of the seven reaches examined. Sediments with elevated concentrations of these and other substances (e.g., DDTs) extended from the sediment-water interface to depths of up to 11.5 feet. More importantly, non-aqueous phase liquids (NAPL) were detected in sediments collected from most of the reaches investigated, suggesting that shallow groundwater may also be contaminated by these substances (FWENC 2003). The results of toxicity tests conducted on the sediment samples collected in this investigation showed that the samples with elevated whole-sediment chemistry were frequently toxic to the amphipod, *Hyalella azteca*, in 28-day exposures (Kemble et al. 2002, 2003).

2.3 FUNCTIONAL EQUIVALENCE OF EXISTING STUDIES TO A REMEDIAL INVESTIGATION

As indicated above, the results of several investigations have demonstrated that the WBGCR has been contaminated by toxic and bioaccumulative substances. The concentrations of a number of these substances in whole sediments and/or pore water are sufficient to injure bed sediments and sediment-dwelling organisms (Ingersoll and MacDonald 1999; MacDonald and Ingersoll 2000; MacDonald et al. 2002a). In addition, direct exposure to contaminated sediments has been shown to cause toxicity in benthic macroinvertebrates and fish (Simon 1986; Hoke et al. 1993; Kemble et al. 2002, 2003). Adverse effects on wildlife, through bioaccumulation in the food web, are also predicted based on the concentrations of certain COCs in bed sediments (MacDonald et al. 2000, 2002b).

In response to concerns regarding environmental contamination and the potential for associated effects on human health and ecological receptors, it would not be unreasonable to conduct an environmental impact statement (EIS) or formal remedial investigation/feasibility study (RI/FS) in the WBGCR to assess the risks posed to human health and the environment associated with exposure to COCs. Remedial investigations and associated feasibility studies are typically undertaken at hazardous waste sites that are being addressed under CERCLA (i.e., for National Priority List sites and certain cooperative sites). The WBGCR is not a CERCLA (Superfund) site and it is not listed under Indiana's state cleanup program, therefore the formal RI/FS process does not apply. However, the documents and investigations that are being prepared and

conducted are the building blocks of an EIS and are similar in many ways to an RI/FS. In general, RIs typically involve development of a conceptual site model (CSM), assessment of the fate and transport of COPCs, evaluation of the nature and extent of contamination, assessment of risks to ecological receptors, and assessment of risks to human health. Although a formal EIS or RI/FS has not been conducted on the WBGCR, it can be reasonably argued that the work that has been completed to date is consistent with the EIS process for the following reasons:

- Information on the key elements of a CSM (i.e., sources and releases of COPCs, environmental fate of COPCs, potential exposure pathways, and ecological receptors at risk) has been generated by various investigators and summarized by the Natural Resources Trustees (1997) in a manner that facilitated the development of a plan that could be used to assess injury to natural resources. More-specific CSMs for the WBGCR, that integrate the information from various sources, will be presented in the baseline human health risk assessment (BHHRA) and the risk-based PRG report;
- The fate and transport of COPCs in the WBGCR was evaluated by Bierman (1995);
- Two major sediment characterization efforts along the entire WBGCR to document the nature and spatial extent of contamination in surface and subsurface sediments were conducted by FWENC (2002b; 2003) and related investigations (MacDonald et al. 2000; 2002a; 2002b; 2003a);
- The equivalent of a screening-level ecological risk assessment (ERA) was conducted to assess injury to benthic invertebrates, fish, and wildlife in the WBGCR (MacDonald et al. 2000; 2002a; 2002b);
- The equivalent of the baseline ERA was conducted to assess injury to sediments and sediment-dwelling organisms in the WBGCR (Ingersoll and MacDonald 1999; MacDonald et al. 2000; 2002a); that is, a risk-based approach was used in the assessments and the results were supported by multiple lines of evidence; and,
- A baseline human health risk assessment (HHRA) will be completed by TtEC (2005). Injury to human uses of the WBGCR was assessed in an earlier investigation (MacDonald et al. 2003a).

Work completed by USFWS, IDEM, and others on the WBGCR provides the information needed to estimate the risks posed by environmental contaminants to ecological receptors in the WBGCR. The GCRRF Council decided to expedite the restoration alternatives development and evaluation process by focusing on key receptor groups (i.e., the benthic invertebrate community) and developing risk-based tools that can be used to classify sediment samples in terms of the risks that they pose to benthic infauna. This decision was made with the understanding that the

microbial, aquatic plant, and fish communities are typically less sensitive to the COPCs that occur in WBGCR sediments than are benthic invertebrates (i.e., toxicity thresholds for whole-sediment chemistry that are protective of the benthic invertebrate community are typically lower than those for the other receptor groups; MacDonald et al. 2003b).

In making this decision, the GCRRF Council also considered the uncertainties associated with assessing risks to wildlife associated with indirect exposure to sediment-associated COPCs (i.e., through bioaccumulation and associated dietary exposure), and recognized that monitoring tissue residue levels in aquatic organisms during the restoration process would provide a more direct means of evaluating risks to aquatic-dependent wildlife. It was further understood that remediation of contaminated sediments to address risks to the benthic community would likely reduce risks to wildlife (i.e., by reducing the concentrations of bioaccumulative COPCs in sediments and, thereby, resulting in lower levels of tissue-associated COPCs), and that application of a “virtual remediation approach” would provide a basis for determining if such risks would likely be reduced to tolerable levels. (A more detailed description of this procedure will be included in the restoration alternatives report.)

3. APPROACH TO THE DEVELOPMENT AND EVALUATION OF RESTORATION ALTERNATIVES FOR THE WEST BRANCH OF THE GRAND CALUMET RIVER

The GCRRF was established by Trust Agreement following settlement of the civil action case against Industrial Users of the Sanitary District of Hammond wastewater treatment facilities (i.e., *United States of America v. The Sanitary District of Hammond et al.*). The fund was established to address and correct environmental contamination in the Area of Concern, including the remediation of contaminated sediment and the restoration of natural resources damages in the vicinity of the WBGCR. As established in a MOU between IDEM, IDNR, USFWS, and EPA (i.e., the Parties), the GCRRF Council was established in 1997 to administer the fund and to coordinate the activities of the Parties to achieve the maximum environmental benefit.

Under the terms of the MOU, the GCRRF Council is authorized and directed to engage in a variety of activities, including:

- Conduct and oversee scientific and technical studies, sampling, and other activities necessary to the development and implementation of sediment remedial action plans and natural resources restoration plans;
- Make all necessary decisions for the management and administration of funds in the GCRRF in accordance with applicable laws and the MOU; and
- Arrange contracts with professional consultants as necessary to provide services to the Parties to undertake activities pursuant to the MOU and GCRRF Trust Agreement.

Consistent with its terms of reference, development and evaluation of restoration alternatives for cleaning up contaminated sediment and restoring natural resources in the WBGCR was identified as the GCRRF Council's highest priority. This project was divided into three phases. The first phase of the project involved compilation of historical information on sediment contamination and identification of data gaps that needed to be filled before restoration alternatives could be developed. The results of that portion of the study are presented in the technical memorandum entitled, *Restoration Alternatives Development and Evaluation, West Branch of the Grand Calumet River, Indiana* (FWENC 2002a). In response to information requirements identified in the data gap analysis, the GCRRF Council initiated a series of investigations in 2002 to better characterize environmental conditions in the WBGCR. The results of these studies provide detailed information on the physical, chemical, and toxicological characteristics of Roxana Marsh (FWENC 2002b; Kemble et al. 2002) and the WBGCR (FWENC 2003; Kemble et al. 2003). Once the critical information needs had been met, the GCRRF proceeded with the third

phase of the project, development and evaluation of restoration alternatives. The approach that is being used to generate the information needed to select the preferred restoration alternative(s) for the WBGCR is described below.

3.1 APPROACH TO THE DEVELOPMENT AND EVALUATION OF RESTORATION ALTERNATIVES

Following completion of the first two phases of the project, Phase 3 was initiated to develop and evaluate remedial alternatives for the WBGCR. This phase of the project involves a number of activities to provide risk managers and the public with the information needed to select the preferred remedial alternative for addressing concerns relative to contaminated sediments in the WBGCR, including:

- Development of RAOs (this document);
- Assessment of risks to human health associated with exposure to surface water, sediments, and aquatic organisms in the WBGCR under baseline conditions (in progress);
- Development of risk-based PRGs for ecological receptors in the WBGCR (in progress);
- Development of alternatives for remediating contaminated sediments and restoring natural resources in the WBGCR (in progress); and,
- Selection of the preferred alternatives for cleaning up contaminated sediments and restoring natural resources in the WBGCR. This is a public process and input received from the public comments will be incorporated and integrated into the final selection process.

Each of these steps is briefly described in the following sections.

3.1.1 Development of Remedial Action Objectives

The development of RAOs represents an essential element of the overall restoration alternatives development and evaluation process. The RAOs are needed to clearly articulate the intent of any remedial activities that may be undertaken to address risks to human health or ecological receptors at a site. In this study, RAOs were developed by reviewing the input that had been provided previously by the public on the desired future conditions of the WBGCR and translating it into long-term ecosystem goals and objectives. Subsequently, these ecosystem goals and objectives were used to articulate RAOs that apply to surface water, sediments, and biological tissues (the RAOs that were developed are presented in Chapter 4 of this report).

The RAOs articulated in this document describe the narrative intent that any remedial actions that are implemented on the WBGCR will need to meet to address risks to human health and the

ecological receptors. As part of its mandate, the GCRRF Council will develop PRGs that define the concentrations of COCs in the whole sediment that need to be achieved to protect human health and the environment. However, the GCRRF Council is not mandated to address concerns related to contaminated surface water or biological tissues directly. While remedial measures that reduce exposure to contaminated sediments are likely to decrease loadings of COCs to surface water and reduce the accumulation of COCs in fish and other aquatic organisms, further actions will be needed to ensure that the RAOs for the other media are met in the WBGCR (i.e., actions beyond the scope of those that can be implemented by the GCRRF Council, such as source control). Therefore, coordination with other federal and state government programs (e.g., VRP, TMDL) will be required to restore environmental conditions in the WBGCR to a state that will support the designated uses of the aquatic ecosystem.

3.1.2 Assessment of Risks to Human Health

As part of the overall restoration alternatives development and restoration process, an investigation will be conducted to assess the risks to human health in the WBGCR. The objective of the baseline HHRA is to characterize potential human health risks associated with exposure to surface water, sediments, and aquatic organisms containing hazardous substances at the site in the absence of any further remedial action (i.e., under baseline conditions). The baseline HHRA is also intended to identify data needs for any pathways that may present a significant risk to human health, but require additional data in order to be adequately quantified. In accordance with applicable regulatory requirements and guidance documents, the baseline HHRA will consist of five main elements, including: 1) data evaluation; 2) exposure assessment; 3) toxicity assessment; 4) risk characterization; and 5) uncertainty analysis. More-detailed descriptions of the approach to conduct the baseline HHRA are provided in Appendix 1 of this document.

3.1.3 Development of Risk-Based Preliminary Remediation Goals

The RAOs for surface water, whole sediment and pore water, and biological tissues that address risks to ecological receptors associated with exposure to contaminated environmental media in the WBGCR are presented in Chapter 4 of this document. The primary focus of the RAO development is the impact of the contaminated sediments on the benthic invertebrate communities. Secondary RAOs will address other aquatic receptors, aquatic-dependent wildlife, and humans. While such RAOs define the narrative intent that any remedial actions that may be undertaken to address these risks will need to meet, numerical PRGs are also required to support the evaluation of restoration alternatives for the site. Such PRGs define the concentrations of

COCs in the affected media that correspond to the RAOs (i.e., that will be protective of ecological receptors in the WBGCR).

A step-wise approach will be used to support the development of ecological risk-based PRGs for the WBGCR. The first step in this process involves the establishment of RAOs for whole sediment. Next, the COCs in the WBGCR will be identified based on the results of the sediment injury assessments completed earlier (Ingersoll and MacDonald 1999; MacDonald and Ingersoll 2000; MacDonald et al. 2002a; 2002b) and recent investigations (Kemble, et al. 2002, 2003; FWENC 2002b, 2003). A conceptual site model will be developed to describe key exposure pathways and receptors at risk. This information will then be used to develop risk hypotheses that supported the identification of key assessment endpoints. Finally, PRGs for benthic invertebrates will be developed and evaluated using matching whole-sediment chemistry and toxicity data from the WBGCR (and other areas, when necessary). The PRGs will focus on sediment-dwelling organisms because the results of several other studies indicated that benthic invertebrates were as much or more sensitive to contaminated sediments than were fish or other aquatic organisms (Burton 1994; Kemble et al. 1994; MacDonald et al. 2002b). More detailed descriptions of the approach that was used to derive the risk-based PRGs for ecological receptors are provided in Appendix 2 and MacDonald et al. (2005). The PRGs that are ultimately recommended to support the evaluation of restoration alternatives for the WBGCR will be presented in the Restoration Alternatives report.

3.1.4 Development, Evaluation, and Selection of Restoration Alternatives

Following the completion of the baseline HHRA and the development of PRGs for the ecological receptors, restoration alternatives for remediating contaminated sediments and restoring natural resources in the WBGCR will be developed and evaluated. As a first step in the restoration alternatives development process, the river reaches in the WBGCR will be delineated. Next, potentially applicable technologies for addressing and correcting sediment contamination will be identified and screened against a series of evaluation criteria. Finally, a number of reach-specific restoration alternatives will be developed and used to formulate river-wide restoration alternatives. The short- and long-terms risks associated with each of the candidate remedies will then be evaluated to provide a basis for determining the level of protection that they would offer to human health and ecological receptors.

The evaluation of restoration alternatives involves three main steps, including developing evaluation/ranking criteria, screening the candidate restoration alternatives using the evaluation criteria (i.e., comparative analysis), and formulating recommendations for the GCRRF Council and the public relative to the preferred restoration alternative. In the first step of the evaluation process, standard criteria for assessing restoration alternatives are compiled from various sources

(e.g., IEc 2004), along with additional criteria that are directly applicable to the site. Following the finalization of the evaluation criteria, they are used to rank the candidate restoration alternatives that were identified previously. Any uncertainties or data gaps will be noted at that time. Finally, the results of the comparative analysis will be used to recommend the preferred restoration alternative(s) for addressing and correcting contaminated sediments in the WBGCR. The recommended restoration alternative(s) and the other candidate alternatives will then be presented to the GCRRF Council and public to facilitate the selection of the option(s) that would achieve maximum environmental benefit.

4. DEVELOPMENT OF PRELIMINARY REMEDIAL ACTION OBJECTIVES

RAOs provide the foundation upon which restoration cleanup alternatives are developed. RAOs are usually developed once risk managers have determined that significant risks to human health and/or the environments are present at a site. These risks, together with other regulatory requirements (e.g., applicable or relevant and appropriate requirements [ARARs]), are considered as the RAOs are defined. As discussed in Chapter 2, significant risks to human health and the environment have been documented for the WBGCR.

RAOs are required to support remedial action planning for the WBGCR. The RAOs are needed to clearly articulate the intent of any remedial actions that may be undertaken to address risks to human health and/or ecological receptors at the site. PRGs are then developed to address the RAOs. PRGs are the target concentrations in the affected media that correspond to the specific RAOs. For example: if the RAO is protection of humans from incidental ingestion of sediments during recreational activities, the PRG may be the concentrations of the COCs that correspond to an acceptable risk level.

Establishment of RAOs, and associated PRGs, will also enable risk managers to evaluate the various remedial alternatives that are identified for the WBGCR relative to their ability to reduce risks to human health and ecological receptors to acceptable levels and their relative costs. The development of RAOs requires a long-term vision for the water body that reflects the interests and needs of stakeholders, as articulated in ecosystem goals and objectives (Section 4.1). The following subsections describe candidate ecosystem goals, ecosystem objectives, and preliminary RAOs that were developed based on the current understanding of the stakeholder interests, as expressed by the GCRRF Council. The GCRRF Council has held ten public meetings since February 20, 2002 to gain such public input. It is anticipated that these RAOs may be further refined based on additional comments that are provided by the public.

4.1 LONG-TERM ECOSYSTEM GOALS AND OBJECTIVES

Ecosystem goals are broad narrative statements that define the management goals that have been established for a specific ecosystem. Definition of management goals for the aquatic ecosystem is a fundamental step towards the development of defensible plans for assessing and managing the ecosystem under investigation. Establishment of ecosystem goals requires input from a number of sources to ensure that societal values are adequately represented. Open consultation with the public is the primary source of information for defining these goals; however, input from government agencies, non-government agencies, and other stakeholders is also essential to the

process. Importantly, information on the past, current, and potential future uses of the aquatic resources within the basin should be solicited to support the development of ecosystem goals.

Restoration of natural resources and their uses has been identified as an important long-term goal for the WBGCR. However, this goal is too general to support the development of meaningful planning, research, and management initiatives for the WBGCR. To be useful, this ecosystem goal must be further clarified and refined to establish specific objectives that are more closely linked with ecosystem science (Harris et al. 1987). In turn, more-specific ecosystem objectives support the identification of indicators and metrics that provide the information needed to more directly assess the health and integrity of the ecosystem. (See MacDonald and Ingersoll [2002] for a more detailed discussion of the ecosystem-based framework for assessing and managing contaminated sediments.)

As indicated earlier in this document, in order to expedite the restoration alternative development and evaluation process, the RAOs will focus on the benthic invertebrate community as the key ecological receptor group; that is, risk-based tools will be used to classify sediment in terms of the risks that they pose to benthos. The GCRRF Council made this decision based on the fact that benthic invertebrates are typically more sensitive to the WBGCR COPCs than other ecological receptors (e.g., microbial, aquatic plant, and fish communities). It is generally believed for the WBGCR that remediating the contaminated sediments and focusing on the reduction of risks to the benthic community will result in a corresponding reduction of risks to wildlife by reducing the concentrations of COPCs that bioaccumulate in sediments.

The following is a list of some of the ecosystem objectives that have been identified to date (see <http://www.in.gov/idem/land/federal/nrda/grandcalumet/index.html>):

- Restore benthic conditions to a state that will support a healthy and diverse benthic community;
- Restore aquatic environmental conditions to a state that will:
 - reduce the incidence, magnitude, and extent of undesirable algal growth (eutrophication) and support healthy and diverse periphyton communities,
 - support a healthy and diverse fish community (at minimum, conditions should be sufficient to support a balanced warm-water fishery),
 - reduce the incidence of fish tumors and other deformities to background levels,
 - reduce the incidence of bird or animal deformities or reproductive problems to background levels, and
 - reduce the frequency of, or eliminate, fish consumption advisories;

- Restore aquatic, wetland, and terrestrial habitats to a state that will support healthy, diverse, and self-sustaining populations of aquatic-dependent avian and mammalian species; and
- Restore other human uses of the WBGCR, including primary contact recreation (i.e., swimming and wading) and secondary contact recreation (i.e., boating, hiking, etc.).

These ecosystem objectives provide a basis for establishing RAOs that reflect the interests and needs of stakeholders relative to the restoration of natural resource values within the WBGCR. In addition, achievement of these ecosystem objectives would eliminate 11 of the 14 use impairments that were identified in the Stage One Remedial Action Plan (RAP) for the IHAOC (IDEM 1991). The other use impairments that were identified in the Stage One RAP were related to drinking water quality, navigational dredging, and associated effects on agriculture and industry, and are not relevant to the WBGCR. Therefore, ecosystem objectives for restoring these beneficial uses were not identified for the WBGCR.

The ecosystem objectives listed above describe the desired future state of the WBGCR ecosystem. While it would be desirable to achieve all of these objectives, past uses of the watershed and ongoing industrial and urban land uses have the potential to influence the feasibility and effectiveness of restoration actions in the basin. Accordingly, it may not be realistic to expect that all of these ecosystem objectives will be achieved in the near term. Based on the preceding discussion, restoration of the benthic conditions will be a primary objective for this site. Nevertheless, it is appropriate to develop RAOs for the WBGCR that reflect these ecosystem objectives and provide a basis for developing restoration plans that will increase the likelihood of meeting them in the longer term.

4.2 PRELIMINARY REMEDIAL ACTION OBJECTIVES

Remedial action objectives are needed for each of the environmental media that have been degraded in association with human activities within the WBGCR, including surface water, ground water, soil, sediment, and biological tissues. However, while this document presents the RAOs for surface water, sediments, and biological tissues, as stated earlier, the GCRRF Council does not have a mandate to develop and implement a restoration plan to address all of these media types. The GCRRF Council was charged specifically to identify remedial alternatives to address contaminated sediment-related issues only. It is anticipated that remedial measures that are implemented to address sediment contamination will also improve surface water quality and reduce the concentrations of bioaccumulative substances in the tissues of aquatic organisms. Concerns relative to surface water quality are also being address by IDEM and the U.S. Army

Corps of Engineers through the development of total maximum daily loads (TMDLs) for selected COPCs in the Grand Calumet River basin.

As a result of this mandate, the RAOs presented in the following subsections have been segregated into primary RAOs (those addressing risks to benthic organisms exposed to contaminated sediments and pore water) and secondary RAOs (those addressing risk to other receptors exposed to sediment, pore water, surface water, and biological tissues).

4.2.1 Primary RAOs

4.2.1.1 Whole Sediment and Pore Water

The primary RAO for whole sediment and pore water that addresses risks to benthic invertebrates associated with direct exposure to contaminated sediments is presented below:

- **RAO for benthic invertebrates:** Minimize or prevent exposure to whole sediment and pore water that are sufficiently contaminated to pose intermediate or high risks, respectively, to the benthic invertebrate communities.

4.2.2 Secondary RAOs

4.2.2.1 Whole Sediment and Pore Water

The secondary RAOs for whole sediment and pore water that address risks to aquatic receptors and humans associated with direct exposure to contaminated sediments are presented below:

- **RAO for aquatic receptors:** Minimize or prevent exposure to whole sediments and pore waters that are sufficiently contaminated to pose intermediate or high risks, respectively, to microbial, aquatic plant, or fish communities (particularly for fish species that use sediment substrates for spawning and/or early rearing).
- **RAO for aquatic-dependent wildlife:** Minimize risks to sediment-probing bird associated with ingestion of sediments during feeding activities.
- **RAO for humans:** Minimize risks to human health associated with direct contact with sediments during primary contact recreation (swimming or wading) or maintenance activities (e.g., maintenance utility workers).

4.2.2.2 Surface Water

The RAOs for surface water that address risks to aquatic receptors, aquatic-dependent wildlife, and human health associated with exposure to contaminated surface water are presented below:

- **RAO for aquatic receptors:** Minimize or prevent exposure to surface waters that are sufficiently contaminated to pose intermediate or high risks, respectively to microorganisms, aquatic plants, aquatic invertebrates, or fish.
- **RAO for aquatic-dependent wildlife:** Minimize risks to avian or mammalian species associated with direct contact with or ingestion of surface waters.
- **RAO for humans:** Minimize risks to human health associated with incidental ingestion of surface waters during primary or secondary contact recreation.

4.2.2.3 Biological Tissues

The RAOs for the tissues of aquatic organisms (i.e., invertebrates and fish) that address risks to fish, aquatic-dependent wildlife, and human health associated with the bioaccumulation of COCs in the food web are presented below:

- **RAO for fish:** Reduce the concentrations of COCs in fish tissues to levels that are not associated with adverse effects on survival, growth, reproduction, or the incidence of lesions or tumors in fish.
- **RAO for aquatic-dependent wildlife:** Reduce the concentrations of COCs in the tissues of prey species to levels that do not pose unacceptable risks to insectivorous birds, sediment-probing birds, carnivorous-wading birds, piscivorous birds, piscivorous mammals, or omnivorous mammals.
- **RAO for humans:** Minimize or prevent exposure to fish tissues that are sufficiently contaminated to pose unacceptable excess lifetime cancer risks. Additionally, prevent exposure to fish tissues that are sufficiently contaminated to cause a non-cancer hazard index of greater than one.

5. SUMMARY

The results of a number of studies demonstrate that surface water, groundwater, sediment, and biological tissues in the WBGCR are contaminated by a variety of toxic and bioaccumulative substances, including heavy metals, PAHs, PCBs, and various other hazardous substances (Ingersoll and MacDonald 1999; MacDonald and Ingersoll 2000; FWENC 2002b; 2003). To address concerns relative to environmental contamination in the WBGCR, the Natural Resources Trustees and others have conducted a variety of studies to assess the impacts of hazardous substances on human health and the environment. The results of these investigations demonstrate that oil and other hazardous substances occur in environmental media in the WBGCR at levels sufficient to adversely affect human health and the environment (EPA 1994; TtEC 2005; Ingersoll and MacDonald 1999; MacDonald and Ingersoll 2000; MacDonald et al. 2002a; 2002b). Toxic effects on certain ecological receptors have also been demonstrated (MacDonald et al. 2000; Kemble et al. 2002; 2003).

Under the authority of CERCLA, CWA, and/or OPA, the Natural Resources Trustees (USFWS, IDEM, and IDNR) are working with EPA to determine what actions are necessary to address natural resource injuries caused by past releases of oil and other hazardous substances into the IHAOC (IEc 2004). Following settlement with the Industrial Users of the Hammond Sanitary District in February, 1997, a Trust Agreement for the GCRRF was established by Memorandum of Understanding among EPA, USFWS, IDEM, and IDNR. The GCRRF Council, which consisted of representatives of each of these agencies, was established at that time. Payments to the GCRRF by settling parties were to address the effects of sediment contamination on human health and the environment. Specifically, the resources were to be used for addressing and correcting environmental contamination in the IHAOC, including cleanup of contaminated sediment in the GCR, remediation of impaired waterways, and restoration of injured natural resources within the IHAOC.

The GCRRF Council is formulating a plan for cleaning up contaminated sediments and restoring natural resources that will be guided by the results of the Restoration Alternatives Development and Evaluation project. This project involves three main phases, including: 1) compilation of historical information on sediment contamination and identification of data gaps; 2) further site characterization to fill the identified data gaps; and 3) development and evaluation of restoration alternatives.

This report is the first in a series of documents that were prepared to support the development and evaluation of restoration alternatives for the WBGCR. More specifically, this document provides an overview of the impacts on human health and the environment associated with

exposure to contaminated water, sediment, and biota in the WBGCR. The process that will be used to develop and evaluate restoration alternatives for the WBGCR, is also described. Finally, the remedial action objectives that were developed to support the restoration alternatives selection process are presented. Subsequent documents in the series will present: 1) the results of the assessment to assess risks to human health associated with exposure to surface water, sediment, and fish in the WBGCR under baseline conditions; 2) the risk-based PRGs for ecological receptors in the WBGCR; and 3) candidate restoration alternatives that will be developed to address risks to human health and ecological receptors, as well as the results of restoration alternatives analysis. Collectively, these work plan products are intended to provide the GCRRF Council and the public with the information needed to select restoration alternatives that effectively address and correct environmental contamination in the WBGCR.

6. REFERENCES

- Bierman, V.J. 1995. Transport and fate of constituents discharged from the Hammond Sanitary District Facility. Submitted to the Environment and Natural Resources Division. United States Department of Justice. Washington, District of Columbia.
- Brannon, J.M., D. Gunnison, D.E. Averett, J.L. Martin, R.L. Chen, and R.F. Athow. 1989. Analysis of Impacts of Bottom Sediments from Grand Calumet River and Indiana Harbor Canal on Water Quality. Report Number D-89-1. Waterways Experiment Station. U.S. Army Corps of Engineers. Vicksburg, Mississippi.
- Bright, G.R. 1988. Recent Water Quality in the Grand Calumet River as Measured by Benthic Invertebrates. *Proceedings of the Indiana Academy of Sciences* 98:229-233.
- Burton, A. 1994. West Branch Grand Calumet River: 1993 Sediment Toxicity Test Data Summaries. Prepared for Environmental Sciences Division. United States Environmental Protection Agency. Region V. Chicago, Illinois.
- Crane, J.L. 1996. "Carcinogenic Human Health Risks Associated with Consuming Contaminated Fish from Five Great Lakes Areas of Concern." *Journal of Great Lakes Management* 22:653-668.
- Dorkin, J. 1994. Sediment Sampling and Analysis Plan – West Branch Grand Calumet River: 1993 Sediment Chemistry Data Summaries. Environmental Science Division, United States Environmental Protection Agency, Region V. Chicago, Illinois. 30 pp.
- EPA (United States Environmental Protection Agency). 1994. Assessment and Remediation of Contaminated Sediments (ARCS) Program: Baseline Human Health Risk Assessment: Grand Calumet River/Indiana Harbor Canal, Indiana, Area of Concern. EPA 905-R94-025. Great Lakes National Program Office. October.
- FWENC (Foster Wheeler Environmental Corporation). 2002a. Technical Memorandum: Restoration Alternatives Development and Evaluation, West Branch of the Grand Calumet River, Indiana. Prepared for the U.S. Fish & Wildlife Service by Foster Wheeler Environmental Corporation, Lakewood, Colorado. February 27.
- FWENC. 2002b. Field and Laboratory Data Report for the Chemical, Physical, and Toxicological Characterization of Roxana Marsh. Prepared for the U.S. Fish & Wildlife Service by Foster Wheeler Environmental Corporation, Bothell, Washington. September.

- FWENC. 2003. Site Characterization Report, West Branch of the Grand Calumet River, Lake County, Indiana. Prepared for the U.S. Fish & Wildlife Service by Foster Wheeler Environmental Corporation, Bothell, Washington. August.
- Harris, H.J., P.E. Sager, S. Richman, V.A. Harris, and C.J. Yarbrough. 1987. "Coupling Ecosystem Science with Management: A Great Lakes Perspective from Green Bay, Lake Michigan, USA." *Environmental Management*. 11:619-625.
- HNTB (Howard, Needles, Tammen, and Bergendoff Architects, Engineers, and Planners). 1995. Phase II. Combined sewer overflow master plan. Grand Calumet River Sampling Program. Prepared for the Sanitary District of Hammond, Indiana. Hammond, Indiana.
- Hoke, R.A., J.P. Giesy, M. Zabik, and M. Unger. 1993. "Toxicity of Sediments and Sediment Pore Waters from the Grand Calumet River - Indiana Harbor, Indiana, Area of Concern." *Ecotoxicology and Environmental Safety* 26:86-112.
- IDEM (Indiana Department of Environmental Management). 1991. Remedial Action Plan for the Indiana Harbor Canal, the Grand Calumet River, and Nearshore Lake Michigan: Stage 1. Indianapolis, Indiana (as cited in Natural Resources Trustees 1997).
- IDEM. 2004. List of National Pollutant Discharge Elimination System permits. Updated July 2004.
- IEc (Industrial Economics, Incorporated). 2004. Restoration and Compensation Determination Plan. Grand Calumet River/Indiana Harbor Canal Natural Resource Damage Assessment. Prepared for U.S. Fish and Wildlife Services and Indiana Department of Environmental Management. Bloomington, Indiana.
- IJC (International Joint Commission). 1989. Report on Great Lakes Water Quality. Great Lakes Water Quality Board. Windsor, Ontario. Canada
- Ingersoll, C.G. and D.D. MacDonald. 1999. An Assessment of Sediment Injury in the West Branch of the Grand Calumet River. Volume I. Prepared for Environmental Enforcement Section. Environment and Natural Resources Division. United States Department of Justice. Washington, District of Columbia.
- Kemble, N.E., W.G. Brumbaugh, E.L. Brunson, F.J. Dwyer, C.G. Ingersoll, D.P. Monda, and D.F. Woodward. 1994. "Toxicity of Metal-Contaminated Sediments from the Upper Clark Fork River, Montana, to Aquatic Invertebrates and Fish in Laboratory Exposures." *Environmental Toxicology and Chemistry* 13(12):1985-1997.

- Kemble, N.E., C.G. Ingersoll, and C.D. Ivey. 2002. Preliminary Report on the Assessment of the Toxicity of Sediment from West Branch Grand Calumet River to the Amphipod, *Hyaella azteca*. Columbia Environmental Research Center. United States Geological Survey. Columbia, Missouri.
- Kemble, N.E., C.G. Ingersoll, and C.D. Ivey. 2003. Final Report on the Assessment of the Toxicity of Sediment from West Branch Grand Calumet River to the Amphipod, *Hyaella azteca*. Columbia Environmental Research Center. United States Geological Survey. Columbia, Missouri.
- MacDonald, D.D. and C.G. Ingersoll. 2000. An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan. Prepared for U.S. Fish and Wildlife Service. Bloomington, Indiana.
- MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindscoog, D.W. Sparks, J.R. Smith, T.P. Simon, and M.A. Hanacek. 2002a. "An Assessment of Injury to Sediments and Sediment-Dwelling Organisms in the Grand Calumet River and Indiana Harbor Area of Concern, USA." *Archives of Environmental Contamination and Toxicology* 43:141-155.
- MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindscoog, D.W. Sparks, J.R. Smith, T.P. Simon, and M.A. Hanacek. 2002b. "An Assessment of Injury to Fish and Wildlife Resources in the Grand Calumet River and Indiana Harbor Area of Concern, USA." *Archives of Environmental Contamination and Toxicology* 43:141-155.
- MacDonald, D.D., D.E. Smorong, R.A. Lindscoog, and C.G. Ingersoll. 2003a. An Assessment of Injury to Human Uses of Fisheries Resources in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan. Prepared for U.S. Fish and Wildlife Service. Bloomington, Indiana.
- MacDonald, D.D., R.L. Breton, K. Edelman, M.S. Goldberg, C.G. Ingersoll, R.A. Lindscoog, D.B. MacDonald, D.R.J. Moore, A.V. Pawlitz, D.E. Smorong, and R.P. Thompson. 2003b. Development and Evaluation of Preliminary Remediation Goals for Selected Contaminants of Concern at the Calcasieu Estuary Cooperative Site, Lake Charles, Louisiana. Prepared for U.S. Environmental Protection Agency. Dallas, Texas.
- MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, L. Fisher, C. Huntington, and G. Braun. 2005. Development and Evaluation of Risk-Based Preliminary Remediation Goals for Selected Sediment-Associated Contaminants of Concern in the West Branch of the Grand Calumet River. Prepared for the U.S. Fish and Wildlife Service. Bloomington, Indiana.

- Natural Resources Trustees. 1997. Assessment Plan for the Natural Resource Damage Assessment of the Grand Calumet River, Indiana Harbor Ship Canal, Indiana Harbor, and Associated Lake Michigan Environments. Prepared for U.S. Department of Interior and the State of Indiana. Indianapolis, Indiana.
- Polls, I., S.J. Sedita, D.R. Zenz, and C. Lue-Hing. 1993. A Comparison of the Water and Sediment Quality and Benthic Invertebrates in the Grand Calumet River, the Indiana Harbor Canal, Indiana Harbor, Southwestern Lake Michigan, and the Calumet River during 1982 and 1986. Research and Development Department. Metropolitan Water Reclamation District of Greater Chicago. Chicago, Illinois.
- Ryder, K. 1993. Preliminary Inventory of Industries on the Grand Calumet River, Indiana and Illinois. Environmental and Social Analysis Branch. Chicago District. U.S. Army Corps of Engineers. Chicago, Illinois.
- Simon, T.P. 1986. Sub-Chronic Toxicity Evaluation of Major Point-Source Dischargers in the Grand Calumet River and Indiana Harbor Canal, Indiana, Using the Embryo-Larval Survival and Teratogenicity Test. United States Environmental Protection Agency. Central Regional Laboratory. Chicago, Illinois.
- USGS (U.S. Geological Survey). 2000. Surface Water and Groundwater Hydrology and Contaminant Detections in Groundwater for a Natural Resource Damage Assessment of the Indiana Harbor Canal and Nearshore Lake Michigan Watersheds, Northwestern Indiana.

APPENDIX A

BASELINE HUMAN HEALTH

RISK ASSESSMENT ANALYSIS PLAN

1.0 BASELINE HUMAN HEALTH RISK ASSESSMENT ANALYSIS PLAN

A focused baseline human health risk assessment (BHHRA) will be performed for the West Branch of the Grand Calumet River (WBGCR) site based on the findings of data collected during TtEC's recent site characterization study (August 2003) and selected historical data. The objective of this evaluation will be to characterize potential human health risks associated with exposure to surface water, sediments, and fish containing hazardous substances at the site in the absence of any further remedial action. The BHHRA will also identify data needs for any pathways that may present a significant risk but require additional data in order to be adequately quantified.

The BHHRA will be prepared in accordance with the requirements of applicable regulatory and other guidance documents. Consistent with these guidelines, the BHHRA will consist of the following elements:

- Data Evaluation
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Analysis

The following sections discuss each of the elements of the BHHRA. The preliminary results of the data evaluation task and the conceptual site model (CSM) are also included.

1.1 DATA EVALUATION

Site characterization in the context of human health risk assessment includes the identification of chemicals of potential concern for each distinct area of contaminated environmental media, and development of a conceptual site model.

1.1.1 Identification of Chemicals of Concern

Chemicals of potential concern (COPCs) are chemicals that may be hazardous to human health, and will be identified from analytical data acquired during TtEC's recent site characterization study (August 2003). Historical data will also be utilized, provided that such data are available in electronic format, are of sufficient quality, and can be adequately located on project maps. Surface water data and fish tissue results will be reviewed. Preliminary COPCs for sediments have been identified and the results of this selection process are discussed further below.

The primary criterion to be used for the screening of chemicals as potential COPCs is a comparison of maximum detected concentrations to a toxicity-based concentration screen. Appropriate toxicity-based screening criteria include the most recent EPA Region 9 Preliminary Remediation Goals (PRGs), or other applicable criteria such as Indiana Department of Environmental Management (IDEM's) default residential criteria under the Risk Integration System of Closure. Therefore, the IDEM criteria will be used as the toxicity-based concentration screen after adjusting the values to represent a cancer risk level of 1×10^{-6} or hazard quotient of 0.1 (i.e., the current criteria (IDEM 2004) divided by a factor of 10). If no IDEM criterion is available for a detected chemical, then the Region 9 PRG will be used as a screening criterion. Region 9 PRGs represent a 1×10^{-6} cancer risk level or hazard quotient of 1. Therefore, only those Region 9 PRGs based on non-cancer endpoints need to be divided by 10, so that the concentration corresponds to a hazard quotient of 1. Chemicals detected at maximum concentrations below these screening criteria will not be retained as COPCs unless other contaminant-specific considerations (such as mobility or persistence) or site-specific considerations indicate the chemical should be included in the risk assessment. For the preliminary identification of COPCs, sediment data were screened against IDEM criteria established for residential soil. Surface water data were screened against the IDEM criteria for residential groundwater/Region 9 PRG for drinking water. Surface water data also were screened using Great Lakes Water Quality criteria. Fish data were not screened using toxicity-based screening criteria. The U.S. Food and Drug Administration tolerance levels were not used as screening criteria because they do not represent a uniform risk-based level.

Typically, concentrations of chemicals that are detected in both field samples and blanks are determined to not be significant by EPA if those chemicals are considered by EPA to be common laboratory contaminants and are less than 10 times the maximum amount detected in any blank sample. Likewise, for chemicals not considered by EPA to be common laboratory contaminants, concentrations of those chemicals will not be considered significant if those concentrations are less than 5 times the maximum amount detected in any blank sample. For the preliminary identification of COPCs, chemicals attributable to field or laboratory contamination (e.g., organic chemicals qualified as B) based on guidance in the Functional Guidelines for Organics (EPA 1994) were eliminated because these are not indicators of site-related contamination.

Comparison to background was only used as a criterion for eliminating a constituent as a COPC when no anthropogenic source of that constituent could be identified and the concentrations observed within a reach were less than the maximum detected sediment concentration from Lake Mary. For the preliminary identification of COPCs, the only detected chemical that was eliminated based on this comparison to background was iron in Reach 7 sediments. This

approach is consistent with EPA Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) policy (EPA 2002).

Chemicals considered by EPA to be macronutrients (i.e., magnesium, calcium, potassium, and sodium), and which are characteristically low in toxicity (except at very high doses), will also be eliminated from further evaluation in the risk assessment.

For the BHHRA, summary tables will be prepared of the analytical data collected during the 2003 site characterization investigation and historical data presented in the Sediment Injury Report (MacDonald and Ingersoll 2000) for shallow sediments for each of the seven reaches and Roxana Marsh.

Summary tables will be prepared using surface water data from several sources. Two samples were collected during the site characterization, one from Reach 1 and one from Reach 4. These samples were analyzed for pesticides/polychlorinated biphenyls (PCBs), semivolatile organic carbons (SVOCs), and metals. Surface water samples were collected from Reach 6 pursuant to an investigation of the former Manufactured Gas Plant site in this area. These samples were analyzed for VOCs, SVOCs, metals, and total cyanide. The Hammond Sanitary District (HSD) samples surface water in Reach 5 monthly. These samples are typically analyzed for dissolved and total metals, and various other parameters such as phenol, alkalinity, BOD, TSS, and E. coli. These data were obtained from EPA's STORET database by IDEM and provided to TtEC for incorporation into the WBGCR database.

Summary tables will also be prepared for fish tissue data. Fish samples have been collected on several occasions. Typically whole fish samples were analyzed. In the fall of 2002, the U.S. Fish and Wildlife Service (USFWS) and IDEM conducted fish sampling. These samples were filleted, and only the edible portions of fish tissue were submitted for analysis. Because fillet samples are more representative of what would be ingested by fish consumers, this data set was utilized for this BHHRA. The USFWS/IDEM fish tissue samples were analyzed for PAHs, SVOCs, pesticides, PCBs (both as Aroclors and as congeners), and metals.

The tables will include for each detected analyte, the frequency of detection, detection limit, minimum and maximum detected concentration, mean concentration, location of maximum detected concentration, and the federal/state criteria to which the data are being compared. The tables will also indicate whether or not each chemical will be retained as a COPC. The preliminary results of the screening process for sediments, surface water, and fish are summarized in Tables A-1 to A-21 and are discussed further below.

The site characterization involved collection of samples from shallow sediment samples (0 to 2 feet below ground surface [bgs]), deeper sediment samples (extending from the surface to greater than 7 feet bgs) from Reaches 1 to 7 and Roxana Marsh, and two surface water samples. Sample

interval lengths varied with the thickness of the homogeneous surficial sediment layer. Historical sediment data were included. Historical results include surface sediment samples, shallow sediment samples (extending from the surface to up to 2 feet bgs), and some deeper sediment samples (from the surface to up to 5 feet bgs). There are a few historical sediment sample results that extend from the surface to 9 feet bgs. These results (UH9.4, UG 9 all, UH 8.5, UH 9.2 all, UH 9.4 all, UH9.1, UH9.2, and UH9.3) were not utilized because the boring logs were not available and therefore it could not be determined if the sampled interval was relatively homogeneous. As a result of the screening process, the preliminary sediment COPCs are:

- Reach 1: PCBs (Aroclor 1242, Aroclor 1248, and Aroclor 1260), dieldrin, bis(2-ethylhexyl)phthalate, carbazole, PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene, and pyrene), aluminum, antimony, arsenic, cadmium, chromium, iron, lead, manganese, nickel, and zinc (Table A-1).
- Reach 2: PCBs (Aroclor 1248), 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), pesticides (4,4'-DDE, Total DDT, gamma-BHC or Lindane, total chlordane, dieldrin, toxaphene, heptachlor, hexachlorocyclohexane), carbazole, PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, phenanthrene, and pyrene), aluminum, antimony, arsenic, cadmium, chromium, iron, lead, manganese, mercury and zinc (Table A-2).
- Reach 3: PCBs (Aroclor 1248 and Aroclor 1260), dieldrin, PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(g,h,i)perylene, indeno(1,2,3-c,d)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and phenanthrene), arsenic, cadmium, chromium, lead, and mercury (Table A-3).
- Reach 4: PCBs (Aroclor 1248 and Aroclor 1260), PAHs (acenaphthene, benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, 2-methylnaphthalene, naphthalene, and phenanthrene), antimony, arsenic, cadmium, chromium, iron, lead, manganese, and mercury (Table A-4).
- Reach 5: PCBs (Aroclor 1248), PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene), aluminum, antimony, arsenic, cadmium, iron, lead, and manganese (Table A-5).

- Reach 6: benzene, PAHs (acenaphthene, benzo(a)pyrene, benzo(a)anthracene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, chrysene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene), aluminum, antimony, arsenic, cadmium, chromium, iron, lead, and manganese (Table A-6).
- Reach 7: PCBs (Aroclor 1248 and Aroclor 1260), pesticides (total chlordane, dieldrin, 4,4'-DDE, total DDT, heptachlor, and toxaphene), benzene, PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, chrysene, 2-methylnaphthalene, naphthalene, and phenanthrene) arsenic, cadmium, lead, manganese, and mercury (Table A-7).
- Roxana Marsh: PCBs (Aroclor 1248, Aroclor 1254, and Aroclor 1260), dieldrin, PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and pyrene), arsenic, cadmium, chromium, iron, lead, and mercury (Table A-8).

IDEM supplied surface water data from the STORET database for the Reach 5 monitoring station by Hohman Avenue (USGS fixed station monitor #05536357). Reaches 1 and 4 were collected by TtEC, and Reach 6 data were available from a former ThermoRetec investigation (ThermoRetec 1999). No surface water COPCs were identified for Reaches 2, 3, and 7 because no data were available for these reaches. Examination of Tables A-9 to A-12 indicates that there is little variation in the concentrations detected between the various reaches. Therefore, for the purposes of calculating exposure point concentrations, results from surface water sampling will be combined. The preliminary surface water COPCs identified for each reach are:

- Reach 1: arsenic and lead (Table A-9).
- Reach 4: arsenic and lead (Table A-10).
- Reach 6: naphthalene, chlorodibromomethane, arsenic, and lead (Table A-11).
- Reach 5 monitoring point: aluminum, arsenic, chromium, and lead (Table A-12).

Fish data were summarized by species within each reach. PCB congener results were summarized as "Nondioxin-like PCBs" and as "Dioxin TEQs." The detected analytes, all of which were considered COPCs, are:

- Reach 1, four Carp Filet composite: PCBs, pesticides (alpha- and gamma-chlordane, o,p'-DDD, p,p'-DDD, p,p'-DDE, and trans trans-nonachlor), PAHs (acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, methylnaphthalene, phenanthrene, and pyrene), and metals (chromium, copper, iron, selenium, and zinc) (Table A-13).

- Reach 1 Chinook Fillet: PCBs, pesticides (alpha- and gamma-chlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, and cis- and trans-nonachlor), PAHs (acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, 1-methylnaphthalene, phenanthrene), and metals (chromium, copper, iron, mercury, selenium, and zinc) (Table A-14).
- Reach 1 six Goldfish Fillet composite: PCBs, Bis(2-ethylhexyl) phthalate, PAHs (fluorene, methylnaphthalene, naphthalene), pesticides (alpha- and gamma-chlordane, o,p'-DDD, p,p'-DDD, p,p'-DDE, and trans-nonachlor), and metals (chromium, copper, iron, lead, selenium, and zinc) (Table A-15).
- Reach 1 Steelhead Fillet: PCBs, pesticides (alpha- and gamma-chlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT and cis- and trans-nonachlor), PAHs (acenaphthene, anthracene, fluoranthene, fluorene, methylnaphthalene, and phenanthrene), and metals (chromium, copper, iron, lead, mercury, selenium, and zinc) (Table A-16).
- Reach 2 Chinook Fillet: PCBs, pesticides (alpha-chlordane, o,p'-DDD, p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, and cis- and trans-nonachlor), PAHs (acenaphthene, anthracene, fluoranthene, fluorene, methylnaphthalene, and phenanthrene), and metals (aluminum, chromium, copper, iron, lead, manganese, mercury, selenium, and zinc) (Table A-17).
- Reach 2 six Goldfish Fillet Composite: PCBs, pesticides (alpha- and gamma-chlordane, o,p'-DDD, p,p'-DDD, p,p'-DDE, dieldrin, gamma-BHC, and trans-nonachlor), PAHs (acenaphthene, anthracene, fluorene, and methylnaphthalene), and metals (chromium, copper, iron, selenium, and zinc) (Table A-18).
- Reach 6 two Carp Fillet Composite: PCBs, pesticides (alpha- and gamma-chlordane, o,p'-DDD, p,p'-DDD, p,p'-DDE, dieldrin, and cis- and trans-nonachlor), PAHs (acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(b)fluoranthene, chrysene, fluoranthene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene), and metals (aluminum, chromium, copper, iron, lead, selenium, and zinc) (Table A-19).
- Reach 7 Carp Fillet: PCBs, pesticides (alpha- and gamma-chlordane, o,p'-DDD, p,p'-DDD, p,p'-DDE, dieldrin, and cis- and trans-nonachlor), PAHs (acenaphthene, benzoic acid, fluoranthene, fluorene, 1- and 2-methylnaphthalene, naphthalene, phenanthrene and pyrene), and metals (aluminum, chromium, copper, iron, lead, selenium, and zinc) (Table A-20).
- Reach 7 Goldfish Fillet: PCBs, pesticides (chlordane, o,p'-DDD, p,p'-DDD, p,p'-DDE, dieldrin, and cis- and trans-nonachlor), PAHs (acenaphthene, acenaphthylene,

anthracene, benz(a)anthracene, chrysene, dibenzofuran, fluoranthene, fluorene, methylnaphthalene, naphthalene, phenanthrene and pyrene), and metals (chromium, copper, iron, selenium, and zinc) (Table A-21).

1.1.2 Exposure Point Concentrations

All valid sampling results will be used for assessing exposure point concentrations. In general, qualified analytical results will be included in the calculation of exposure concentrations.

Exposure point concentration (EPC) estimates based on a high proportion of detected concentrations that have been qualified (for example, estimated values), will be identified in the exposure assessment. All EPCs will be summarized, in tabular format, by exposure medium.

Sediment exposure-point concentrations are based on upper confidence limits (UCLs) of the mean concentration. If sufficient surface water and fish tissue data are available, UCLs will also be used as EPCs. If there are not sufficient data for these media, then the maximum detected concentration will be used as the EPC. Following EPA guidelines, where data from chemical analyses provide the basis for exposure point estimates, the 95 percent UCL on the arithmetic mean will be used, with the following qualifications:

- Spatial patterns of contaminant concentrations will be identified and will be taken into account for assessment of exposure point concentrations.
- Estimates will be developed separately for specific “hotspots” or other subsets of data that indicate concentration anomalies.
- Concentration data will be evaluated using the Shapiro-Wilk Test to determine if the data are normally distributed. If the data are non-normal, alternatives to the mean and 95 percent UCL will be investigated, such as the mean and 95 percent UCL on the geometric mean, or other suitable nonparametric statistics. Both the normality testing and estimation of EPCs will be done using the EPA program, ProUCL (Version 2.0), developed for EPA by Lockheed Martin (EPA 2001a).
- In cases where the sample size is small, the calculated 95 percent UCL on the arithmetic mean may be larger than the maximum detected value. This can also occur with “outliers,” that is, when one or two values are substantially larger than the other values in a data set. In this case, the maximum detected contaminant concentration will be used as an estimate of exposure point concentration.

In estimating UCL contaminant concentrations for COPCs, concentrations reported to be below detection limits (BDLs) will be included in the analysis at one-half the sample detection limit. Where one or more BDL samples have detection limits greater than the highest detected value,

these values will not be included in the estimate of the 95 percent UCL. If a substantial proportion of the data set consists of BDLs with high detection limits, the decision will be made on a case-by-case basis to evaluate whether these data will be incorporated into exposure estimates.

1.2 EXPOSURE ASSESSMENT

The exposure assessment will qualitatively and quantitatively estimate the magnitude, frequency, duration, and routes of exposure. The assessment will include three steps: characterization of the exposure setting, identification of complete exposure pathways, and quantification of exposure for each identified receptor group.

1.2.1 Characterization of Exposure Setting

Characterization of the exposure setting involves review of the physical characteristics, as well as on-site/off-site land use patterns of the WBGCR site. These data will form the basis for the exposure pathways and the quantitative exposure assessment. Such data include physical site characteristics such as topography, surface water hydrology, and meteorology.

The BHHRA will focus on existing or currently planned land uses for on-site and off-site areas. Consistent with EPA guidance, realistic current and future land use scenarios will be developed based on guidance provided in the EPA OSWER Directive: Land Use in the CERCLA Remedy Selection Process (EPA 1995).

Land use in the site environs includes residential, recreational, and commercial/industrial uses. The following characterizes land use for each of the seven reaches and Roxana Marsh based on review of aerial photographs and observation made by TtEC personnel during the site characterization. This information will be updated based on the results of the site reconnaissance.

Roxana Marsh—Although access to this area is limited to a gated road, this area is used for recreational purposes.

Reach 1—Industrial land use predominates on the north side of the WBGCR; the south side of the WBGCR is contiguous with Roxana Marsh.

Reach 2—The south side the WBGCR is primarily residential, and includes Roxana Park, a recreational area adjacent to I-90; the park includes a playground and other recreational facilities. On the western end of Reach 2 is Columbia Park, which includes ball fields; the north bank includes the HSD outfall and former sludge lagoons.

Reach 3—Land use south of the WBGCR includes an industrial area next to the Columbia Avenue Bridge as well as residential areas including multifamily dwellings; on the eastern end of

the north bank are ball fields; vacant lots and a mechanic shop are on the western end of the south side of the river.

Reach 4—Open area on south; on the north side is a school with recreational facilities, including athletic fields; to the west is Turner Field Skate Park, which includes a large maintenance or storage area and a recently constructed outdoor skate or roller blade facility; to the south is Peoples Park which includes soccer fields and provides access to the Grand Calumet River Trail.

Reach 5—The south bank of the WBGCR is primarily multifamily residential and includes a recreation area on the eastern side; to the north, land use is primarily industrial/commercial.

Reach 6—The vacant lot on the south side was the location of a former Manufactured Gas Plant; there is a transportation operation on the north bank; an abandoned industrial area is located on the far western end.

Reach 7—The south bank includes a salvage yard and large industrial buildings to the west; on-land use on the north bank is primarily industrial/commercial.

Recreational uses of the river include angling, boating, hiking, walking and use of adjacent parks. Despite annual fish consumption advisories dating from 1986, not all anglers are aware of the advisory and even some of those who are aware of the advisory do not necessarily follow the consumption advisory (Williams et al. 2000). Fish have been documented in reaches 1, 2, 6 and 7. Reaches 3, 4, and 5 currently may be isolated and/or too shallow for fish of edible size.

Residential areas abut the River in reaches 2, 3, 4, and 5. There are residential areas within approximately ¼ mile of reaches 1, 6 and 7. In general, direct access to the River is limited by topography, brush, and/or fencing but is not precluded. Utility pipelines run adjacent to and cross the River in Reaches 1, 2 and Roxana Marsh in several locations, and there are culverts at most of the roads that divide the various reaches.

1.2.2 Exposure Pathways

As discussed in Section 3.1 (see Figure 3-1, CSM), the BHHRA will focus on exposure pathways associated with the remedial action objectives. These pathways include direct contact (dermal absorption and incidental ingestion) with impacted surface water and shallow sediments, and consumption of fish. Direct contact includes incidental ingestion and dermal contact with sediments, and potentially inhalation of particulate-bound COPCs or volatile COPCs in sediments. Potential exposures to deeper sediments, soil, and groundwater are beyond the scope of this focused BHHRA.

The pathway screening step involves systematic examination of each contaminated environmental media, contaminant transport pathway, and exposed population to define which combinations should be evaluated quantitatively. The combinations to be considered will be

those that represent current complete pathways or future pathways (using reasonable assumptions about future land use). The following subsections discuss the preliminary results of the pathway screening steps in terms of potential source areas and release mechanisms (Section 1.2.2.1) and exposure pathways and receptors (Section 1.2.2.2). This information will be modified and updated based on the findings of the site reconnaissance.

1.2.2.1 Potential Source Areas and Release Mechanisms

The principal current sources of COPCs are sediment deposits found in the seven reaches of the WBGCR and Roxana Marsh. The predominant exposure pathway is direct contact with sediments. Exposures to sediment-related COPCs can also occur when sediments are resuspended in the water. Sediment-related COPCs are also taken up by micro and macrofauna that are subsequently ingested by fish. Most of the area is water-covered throughout the year. Reaches 3, 4, and 5 generally have very low water levels, and during periods of limited precipitation, may dry out. During these times, it is possible that the particulate-bound COPCs could be entrained in ambient air.

Only one volatile organic compound, benzene, was detected and is a COPC in Reach 6 and 7 sediments. These areas are typically water-covered, and therefore significant volatilization to ambient air is unlikely because the benzene would first be released to pore water, then to surface water, and ultimately to the atmosphere. Benzene has not been detected in surface water samples. Therefore, this pathway appears to be incomplete under current site conditions. Three VOCs were detected in surface water: chlorodibromomethane, bromoform, and naphthalene. Apparently the chlorodibromomethane and bromoform are present as artifacts of disinfection of the HSD NPDES discharge because trihalomethanes have not been identified in sediments and are not associated with the industrial discharges to the WBGCR. Both chlorodibromomethane and naphthalene were selected as COPCs for surface water. Neither compound meets the “volatile” criteria of having a Henry’s Law constant greater than 10^{-5} (atm-m³/mol) and a molecular weight less than 200 grams per mole.

Although there may be other impacted environmental media (i.e., groundwater) associated with the WBGCR, evaluation of potential human health risks associated with groundwater exposures is beyond the scope of this study.

1.2.2.2 Exposure Pathways and Receptors

Receptors identified for the BHHRA are adult municipal workers or utility workers performing maintenance activities within the WBGCR and Roxana Marsh, adult and child residents who may use the WBGCR and Roxana Marsh for recreation, and regional-based active angler (anglers may also be residents). Exposure pathways associated with maintenance activities include direct contact with sediments and surface water. Direct contact includes both incidental

ingestion of sediment and surface water as well as dermal absorption of COPCs in these media. When working in Reaches 3, 4, and 5 during extended dry periods, exposure may also include inhalation of windborne entrained particulate-bound COPCs. Similarly, adult and child residents may also be exposed to sediment and surface water through direct contact with these media. Fishermen may directly contact sediment and surface water, and would also ingest fish caught from the area. Although residents may also consume fish, the additional risk associated with fish ingestion will be calculated in the active angler scenario, and discussed as an additional component of the risk characterization.

1.2.3 Quantitative Exposure Assessment

The exposure assessment will utilize EPA's reasonable maximum exposure (RME) default exposure factors, where available. Exposure factors for recreational contact with surface water and sediments and for fish consumption will be obtained from EPA guidance documents including the Exposure Factors Handbook (1997a). Every effort will be made to utilize EPA guidance in the selection of exposure factors. Currently, there are no recognized default exposure factors for active anglers. In fact, current guidance encourages the selection of site-specific or area-specific exposure factors (*Estimated Per Capita Fish Consumption in the United States*, EPA 2002). To this end, TtEC performed a review of the available literature for fish consumption rates from the Great Lakes area and identified a fish consumption survey that included the area near the WBGCR (specifically, Indiana Harbor). The survey was sponsored by IDEM and the results were published in June 2000. The risk assessment will include a discussion of how the exposure factors for active angler were selected and how they compare to other estimates.

Complete pathways will be evaluated in detail in the quantitative exposure assessment. Each significant source, release mechanism, pathway, transformation process, and exposure mechanism will be quantified. Provided that sufficient data exist to characterize each significant element of a pathway, the result of the quantitative exposure assessment will be an estimate of COPC reasonable maximum exposure (RME) intakes at exposure points. The RME is the "highest exposure that is reasonably expected to occur at the site." These intake estimates will be used in the risk characterization described in Section 1.4 of this analysis plan.

1.2.4 Fate and Transport Calculations of EPCs

Fate and transport calculations may be required to estimate air concentrations associated with volatilization from surface water. Where significant areas of sediments periodically dry up, such as Reaches 3, 4 and 5, particulate-bound COPCs may become airborne. Simple analytical methods, such as EPA's particulate emission factor (EPA 1996a), will be used to estimate the resulting concentrations of COPCs in air.

Should volatilization of COPCs from sediments be identified as a complete pathway, an appropriate fate and transport model will be identified. In general, the most significant soil parameter affecting the final steady-state flux of volatile contaminants from soil is the air-filled soil porosity. Volatilization from sediments to ambient air is minimal when sediments are saturated or water-covered. Therefore, the potential for VOC-containing sediments to be exposed directly to air will be evaluated. If this pathway is found to be complete, simple analytical models such as EPA's volatilization factor approach will be utilized, as appropriate.

1.2.5 Exposure Factors

For each exposure route and receptor, the BHHRA will summarize, in tabular format, the complete list of assumptions and parameter values, so that the calculations can be verified. To estimate exposure, the RME combines the UCL EPC with upper bound values for exposure factors. Methods and assumptions used in the exposure assessment will conform to EPA guidance (Final Guidelines for Exposure Assessment 1992) and will incorporate EPA draft guidelines for assessing childhood exposure (EPA 2001b).

1.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to identify available evidence regarding the potential for site-specific COPCs to cause adverse effects in exposed individuals or populations; and to provide, where possible, an estimate of the quantitative relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects (EPA 1989). For the BHHRA, the toxicity assessment will include a tabular summary of toxicity values for each COPC.

The toxicity assessment is generally accomplished in two steps: hazard identification and dose-response assessment. The hazard identification determines whether exposure to an agent can cause an increase in the incidence of a particular adverse effect, and whether the adverse health effect is likely to occur in humans (EPA 1989). Hazard identification will be presented by briefly summarizing the toxicological properties and environmental behavior of the COPCs at the WBGCR site.

The toxicity evaluation will also summarize the dose-response evaluation for the COPCs of interest. The dose-response evaluation is the process of evaluating the toxicity information for each COPC and characterizing the relationship between the exposure or dose received and the incidence of adverse health effects in the exposed population (EPA 1989). Both carcinogenic slope factors and non-carcinogenic reference doses are derived that are used in the risk characterization step. Chemical-specific toxicological parameters (i.e., non-carcinogenic reference doses [RfDs] and reference concentrations [RfCs] and cancer slope factors [CSFs] and unit risks) will be obtained from established EPA sources with the following priority (EPA 2003):

- Tier 1: Integrated Risk Information System (IRIS) (EPA 2004);
- Tier 2: Provisional Peer Reviewed Toxicity Values (PPRTVs) from EPA's Superfund Technical Support Center at the National Center for Environmental Assessment; and
- Tier 3: Other Toxicity Values, such as Health Effects Assessment Summary Tables (HEAST) (EPA 1997b), ATSDR Minimal Risk Levels (MRLs), and California Environmental Protection (Cal EPA) toxicity values.

The dose-response data, in addition to exposure assessment information, will be used in the risk characterization of COPCs associated with the WBGCR site. To facilitate the use of these data in risk characterization models, the dose-response data will be summarized in tables, and will include the following information:

- Contaminant of concern;
- Weight-of-Evidence classification (for carcinogens);
- Organ(s) affected;
- Cancer slope factor - Oral CSF - Inhalation Unit Risk Value;
- Non-Cancer Effects - Oral RfD - Inhalation RfC;
- Uncertainty and modifying factors;
- Chronic/subchronic toxicity criteria, where available; and
- Source.

Development of site-specific toxicity values is not anticipated in the current scope of work..

If lead is identified as a COPC, then the Integrated Exposure Uptake Biokinetic (IEUBK) Model will be used to evaluate child receptor populations. For adult exposure to lead, the BHHRA will utilize the Adult Lead Model (EPA 1996b).

1.4 HUMAN HEALTH RISK CHARACTERIZATION

Human health risk characterization models prescribed by the EPA will be used to generate quantitative estimates of lifetime cancer risks, and to assess the potential for the occurrence of non-cancer adverse health effects for RME chemical exposures at each site. Qualitative characterizations of potential health risks will be provided for those contaminants for which no critical toxicity values are available.

For each reach and Roxana Marsh and each exposed population, the results of the quantitative exposure assessment described in Section 1.2 will be combined with the results of the toxicity assessment described in Section 1.3 to serve as inputs to the risk characterization models. Quantitative lifetime exposure or intake estimates for each contaminant will be multiplied by CSFs or unit risk values for each contaminant to provide an estimate of lifetime cancer risks. Cancer risks associated with exposures to multiple contaminants will be summed to provide lifetime risk estimates for each exposure medium and pathway. Non-cancer adverse health effects will be characterized by comparing the calculated receptor-specific chronic exposures, or intakes, of contaminants to route specific RfDs or RfCs. The potential for risks associated with multi-contaminant exposures will be characterized using Hazard Indices, as described in EPA guidance. EPA's action levels may be used to characterize adverse effects associated with lead exposures, if necessary.

Summary tables of risk characterization results will be included in the BHHRA. The results of the risk characterization can be used to identify chemicals of concern (COCs). COCs are those COPCs that exceed target risk levels. Chemicals that individually contribute a carcinogenic risk greater than 1×10^{-6} or a hazard quotient greater than 1 to a particular receptor may be considered to "contribute significantly" to site risks. Generally, preliminary remediation goals PRGs are developed for each COC.

1.5 UNCERTAINTY ANALYSIS

For the BHHRA, the uncertainty analysis will focus on those sources of uncertainty that can be addressed through additional data gathering.

The uncertainty analysis will also include a qualitative evaluation of the most uncertain and sensitive parameters and their likely impact on the results. This would include a qualitative discussion of the factors contributing significantly to the overall uncertainty in the risk characterization. Factors can then be ranked approximately in order of their contribution to uncertainty, and distinctions will be drawn between those factors that are inherent to the risk characterization models themselves (e.g., exposure assessment parameters and toxicity values), and those that are related to data gathering.

1.6 DEVELOPMENT OF HUMAN HEALTH PRGs

PRGs are initial cleanup levels that are: 1) protective of human health and the environment, and 2) comply with applicable or relevant and appropriate Requirements (ARARs). PRGs are developed based on the results of the baseline human health risk assessment and the ecological evaluation. PRGs are used in the analysis of remedial alternatives. PRGs may be modified prior to finalization due to various uncertainties, technical considerations, and remedy selection criteria. PRGs are concentration goals for specific COCs or combinations of chemicals that are tied to specific environmental media and land use combinations. There are two general sources of PRGs: 1) concentration-based ARARs, and 2) concentrations based on risk assessment. ARARs include concentration limits set by other environmental regulations (e.g., the Clean Water Act) and risk-based concentrations. Risk-based concentration PRGs are calculated based on specific exposure conditions and carcinogenic and/or non-carcinogenic toxicity values to correspond to an established risk level (e.g., 1×10^{-6} cancer risk level for carcinogens or a hazard quotient or 1.0 for non-carcinogens).

Pursuant to the development of PRGs for the WBGCR, the results of the BHHRA will be reviewed in the context of identified RAOs. Receptor populations (e.g., active angler) and exposure conditions (e.g., fish consumptions and direct contact with sediments and surface water) developed in the BHHRA that describe exposure pathways identified with specific RAOs (e.g., habitat sufficient to support a put and take fishery) will be used to calculate chemical-specific PRGs for specific risk levels. PRGs will be developed for both a 1×10^{-6} and 1×10^{-5} risk level.

References

- EPA (U.S. Environmental Protection Agency). 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Interim Final. EPA/540/1-89/002. December.
- EPA. 1992. Final Guidelines for Exposure Assessment
- EPA. 1994. Functional Guidelines for Organics.
- EPA. 1995. OSWER Directive: *Land Use in the CERCLA Remedy Selection Process*.
- EPA. 1996a. Soil Screening Guidance: User's Guide. Office of Solid Waste and Emergency Response.
- EPA. 1996b. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. December.
- EPA. 1997a. Exposure Factors Handbook: Volumes I to III. Office of Research and Development.

- EPA. 1997b. Health Effects Assessment Summary Tables (HEAST). Office of Research and Development. EPA/540/R-97/036. July.
- EPA. 2000. Estimated Per Capita Fish Consumption in the United States. EPA-821-R-00-025. Office of Science and Technology.
- EPA. 2001a. ProUCL User's Guide. May.
- EPA. 2001b. Technical Issue Paper: Age Group Recommendations for Assessing Childhood Exposure and the Adequacy of Existing Exposure Factors Data for Children. Risk Assessment Forum. October.
- EPA. 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. Office of Emergency and Remedial Response. EPA 540-R-01-003. September.
- EPA. 2003. Human Health Toxicity Values in Superfund Risk Assessments. Office of Superfund Remediation and Technology Innovation, Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-53. December.
- EPA. 2004. Integrated Risk Information System (IRIS) on-line database. Date last searched: February.
- FWENC (Foster Wheeler Environmental Corporation). 2003. Site Characterization Report, West Branch of the Grand Calumet River, Lake County, Indiana. Prepared for the U.S. Fish & Wildlife Service by Foster Wheeler Environmental Corporation, Bothell, Washington. August.
- IDEM (Indiana Department of Environmental Management). 2004. Risk Integrated System of Closure: Default Closure Tables.
- MacDonald, D.D., and C.G. Ingersoll. 2000. An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan. Prepared by Donald D. MacDonald, MacDonald Environmental Sciences Ltd., and Christopher G. Ingersoll, Columbia Environmental Research Center, U.S. Geological Survey, in association with Industrial Economics, Inc. for U.S. Fish and Wildlife Service, Bloomington, Indiana. October.
- ThermoRetec Consulting Corp. 1999. River Sediment Investigation Report. Grand Calumet River. Hammond, Indiana. Prepared by ThermoRetec Consulting Corp. for Northern Indiana Public Service Company. Merrillville, Indiana. March.
- Williams, R.L, J.T. O'Leary, A.L. Sheaffer, and D. Mason. 2000. An Examination of Fish Consumption by Indiana Recreational Anglers: An On-Site Survey. Prepared for Indiana Department of Environmental Management. June.

APPENDIX B

ANALYSIS PLAN FOR DEVELOPING AND EVALUATING RISK-BASED PRELIMINARY REMEDIATION GOALS FOR AQUATIC RECEPTORS IN THE WEST BRANCH OF THE GRAND CALUMET RIVER

1.0 Introduction

This investigation was initiated to provide the Grand Calumet River Restoration Fund (GCRRF) Council with ecological risk-based preliminary remediation goals (PRGs) for evaluating various remedial alternatives for the West Branch Grand Calumet River (WBGCR). A step-wise approach will be used in this study to derive such PRGs, which includes:

- Establishment of remedial action objectives (RAOs);
- Identification of chemicals of concern (COCs);
- Development of a conceptual site model (CSM);
- Compilation of matching sediment chemistry and toxicity data;
- Development of initial PRGs for the benthic invertebrate community (i.e., benthic PRGs);
- Evaluation of the reliability of benthic PRGs; and,
- Final selection of PRGs for benthic receptors.

Each of these steps is described in the following sections of this appendix.

2.0 Establishment of Remedial Action Objectives

The first step in the PRG development process involves the establishment of RAOs for the WBGCR that apply to aquatic organisms. RAOs are intended to describe the narrative intent of any remedial actions that are undertaken to address risks to the ecological receptors that are exposed to COCs in the WBGCR. That is, the RAOs describe the desired future condition of the study area, once remedial actions have been completed. RAOs are important because they provide a basis for risk managers and the public to establish a shared vision for the future in a manner that guides the remedial action planning process. The process that will be used to establish the RAOs for water, sediment, and biota in the WBGCR involves soliciting input from GCRRF Council members regarding the interests and needs that have been expressed by government agencies, non-governmental organizations, and the public regarding the past, current, and future uses of the WBGCR. Using this information, the GCRRF Council members will be asked to articulate ecosystem goals and objectives for the WBGCR that define the desired future condition of the river, based on the input that they have received from stakeholders at various public meetings conducted within the region. These ecosystem goals and objectives will then be used to develop draft RAOs that describe the narrative intent of any remedial actions that are undertaken to address risks to aquatic receptors at the site. Subsequently, the draft RAOs will be reviewed and refined by the risk managers to ensure that they will meet their needs during the remedial action planning (RAP) process.

3.0 Identification of Chemical of Concern

Identification of COCs represents an essential element of the overall PRG development process. Ingersoll and MacDonald (1999) assessed sediment injury in the WBGCR. Subsequently, MacDonald and Ingersoll (2000) assessed injury to sediments and sediment-dwelling organisms in the Indiana Harbor Area of Concern, including the WBGCR. In addition to determining if sediment injury had occurred in the WBGCR, these investigators evaluated the spatial extent of sediment injury and identified the toxic and bioaccumulative COCs within the study area. Therefore, the results of these two investigations will be used to establish the COCs for ecological receptors for the WBGCR.

4.0 Development of a Conceptual Site Model

The third step in the PRG development process involves the development of a conceptual site model (CSM) that describes the key relationships between stressors and receptors in the WBGCR. The CSM will be developed by compiling information on the sources and releases of COCs, the fate and transport of COCs, and the potential effects of these COCs on ecological receptors utilizing habitats in the WBGCR. This information will then be used to identify the assessment endpoints of greatest importance relative to ecological receptors that are exposed to contaminated sediments, either directly or indirectly.

5.0 Compilation of Matching Sediment Chemistry and Toxicity Data

Development of site-specific PRGs for the WBGCR necessitates the compilation of matching sediment chemistry and sediment toxicity from the study area (MacDonald et al. 2003a). To support the assessment of sediment injury in the WBGCR and Indiana Harbor Area of Concern (IHAOC), the matching sediment chemistry and sediment toxicity data from the study area were acquired, evaluated, and compiled in a relational database in Microsoft Access format (Ingersoll and MacDonald 1999; MacDonald and Ingersoll 2000). Since the original database was developed, several additional data sets on the WBGCR have been generated, including additional assessments of sediment toxicity in Roxana Marsh (Kemble et al. 2002; FWENC 2002), in WBGCR mainstem (Kemble et al. 2003; FWENC 2003), and in the East Chicago Sanitary District (ECSO) outfall stream (ASCI 2001). These data sets will be acquired and evaluated to determine if they meet project data quality objectives. The data sets that meet these selection criteria have been and will continue to be incorporated into the project database.

Compilation of the requisite information to support PRG development will necessitate decisions on the treatment of certain types of data. For example, additional sediment samples were collected and/or analyzed in a number of studies as part of the quality assurance program. In this analysis, field replicate samples will be treated as unique samples in the data analyses (i.e., by providing information on the small-scale spatial variability in sediment quality conditions). By

comparison, laboratory split samples will be treated as duplicates and averaged to support subsequent data analysis.

To support subsequent interpretation of the sediment chemistry data, the total concentrations of several chemical classes will be determined for each sediment sample. Specifically, the concentrations of total PAHs will be calculated by summing the concentrations of up to 13 individual PAHs, including acenaphthene, acenaphthylene, anthracene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, benz(a)anthracene, dibenz(a,h)anthracene, benzo(a)pyrene, chrysene, fluoranthene, and pyrene. For PCBs, the concentrations of total PCBs will be determined using various procedures, depending on how the data were reported in the original study. If only the concentrations of total PCBs was reported in the study, then those values will be used directly. If the concentrations of various Aroclors (e.g., Aroclor 1242, Aroclor 1248) were reported, then the concentrations of the various Aroclors will be summed to determine the concentration of total PCBs. When the concentrations of the 16 to 20 National Institute of Standards and Technology (NIST) congeners were reported (Lauenstein and Cantillo 1993), then these concentrations will be summed and multiplied by 2.1 to estimate total PCB concentrations. When the concentrations of more than 20 individual congeners were reported, these values will be summed to determine total PCB concentrations. If both Aroclors and PCB congeners were measured, then the higher sums calculated using the two procedures will be used to establish the concentration of total PCBs.

In calculating the total concentrations of the various chemical classes, less than detection limit values will be assigned a value of one-half of the detection limit, except when the detection limit was greater than the consensus-based probable effect concentration (PEC; or an alternate sediment quality guideline if a PEC is not available). In this latter case, the less than detection limit result will not be used in the calculation of the total concentration of the substance.

Simple chemical mixture models will be developed to support the development of risk-based PRGs (MacDonald et al. 2000; EPA 2000; Ingersoll et al. 2001; MacDonald et al. 2002, 2003a). To facilitate the development of these models, PEC-quotients (PEC-Qs; i.e., COC concentration divided by the corresponding PEC) will be calculated for each chemical and chemical class included in the list of COCs, on a dry weight (DW) basis or an organic carbon (OC)-normalized (i.e., at 1 percent OC) basis. Subsequently, mean PEC-Qs for metals will be calculated for each sample using the PEC-Qs that were determined for up to eight metals (i.e., arsenic, cadmium, chromium, copper, lead, nickel, mercury, zinc). The PEC-Qs for total PAHs and total PCBs will be used directly to develop the chemical mixture models. In total, nine chemical mixtures will be considered, including:

- Mean PEC-Q_{metals (DW)};
- Mean PEC-Q_{metals (DW@1 percentOC)};

- $PEC-Q_{tPAH (DW)}$;
- $PEC-Q_{tPAH (DW@1 \text{ percentOC})}$;
- $PEC-Q_{tPCB (DW)}$;
- $PEC-Q_{tPCB (DW@1 \text{ percentOC})}$;
- Mean $PEC-Q_{metals (DW)}$, $tPAHs (DW)$, $tPCBs (DW)$;
- Mean $PEC-Q_{metals (DW@1 \text{ percentOC})}$, $tPAHs (DW@1 \text{ percentOC})$, $tPCBs (DW@1 \text{ percentOC})$; and,
- Mean $PEC-Q_{metals (DW)}$, $tPAHs (DW@1 \text{ percentOC})$, $tPCBs (DW@1 \text{ percentOC})$.

To support the compilation and subsequent analysis of the information on sediment quality conditions in the Area of Concern, a relational project database will be developed in Microsoft Access format. All of the chemistry, toxicity, and benthic community data compiled in the database will be georeferenced to facilitate mapping and spatial analysis using geographic information system (GIS)-based applications (i.e., ESRI's ArcView and Spatial Analyst programs).

6.0 Development of Initial Preliminary Remediation Goals for the Benthic Invertebrate Community

Initial PRGs for the benthic invertebrate community will be developed for each of the COCs and the various chemical mixtures using the following procedures. In the first step of the process, the matching sediment chemistry and sediment toxicity data that are most relevant for deriving concentration-response relationships will be identified. More specifically, the results of 28-d toxicity tests with the amphipod, *Hyalella azteca*, conducted on whole-sediment samples from the WBGCR will be used preferentially in the derivation of PRGs. These data will be augmented by the results of 10-d whole-sediment toxicity tests in the WBGCR database that are designated as toxic to the amphipod, *Hyalella azteca*. This species will be targeted for data collection due to its relative sensitivity and availability of high quality data. These latter data will be compiled along with the 28-d toxicity tests results assuming samples that are found to be toxic in 10-d exposures would also be toxic if the duration of exposure had been extended to 28 days. Samples that were found to be not toxic in 10-d toxicity tests with this species will not be used, however (i.e., as it was not possible to determine if such samples would be toxic or not toxic in 28-d exposures). The results of toxicity tests that employed photoactivation will not be used to derive the PRGs.

In the second step of the process, reference sediment samples will be identified. In this investigation, a reference sediment will be defined as a whole sediment from a location near the area of concern used to assess sediment conditions exclusive of the material(s) of interest (ASTM 2004; E1706). To identify reference sediment samples, the project database will be

screened to identify samples from the Indiana Harbor Area of Concern (IHAOC) in which the concentrations of all measured COCs were less than the corresponding threshold effect concentration (TEC; MacDonald et al. 2000) and mean PEC-Qs were <0.1 (EPA 2000; Ingersoll et al. 2000; MacDonald et al. 2003b). The samples that meet these criteria will be used to define the normal range of background conditions (i.e., the 95 percent prediction limits).

Next, the matching sediment chemistry data for each COC and COC mixture will be extracted from the project database. These data will then be sorted in order of ascending concentrations and compiled into groups of 15 samples. For each group of samples, the average concentration of the COC or COC mixture, the average survival of amphipods, and the incidence of toxicity (i.e., proportion of samples that were toxic) will be determined. These summarized data will then be plotted and used to develop site-specific concentration-response relationships (i.e., by fitting non-linear regressions to the data; Ingersoll *et al.* 2001; MacDonald *et al.* 2002c; 2003b). The summarized data will be fitted using three-parameter sigmoidal models, four-parameter sigmoidal models, three-parameter logistic models, or four-parameter logistic models. The model of best fit will be selected based on a visual examination of the plot and the resultant correlation coefficient (r^2 value). Only statistically significant regressions ($p < 0.05$) will be used to define the concentration-response relationships. Such relationships will be developed based on the observed incidence of toxicity (IOT; percent toxic samples) and the observed magnitude of toxicity (MOT; percent mortality).

For certain substances (e.g., total PCBs), the available matching sediment chemistry and sediment toxicity data from the WBGCR may not be sufficient to support the derivation of significant, site-specific concentration-response relationships. In such cases, it will be necessary to augment the available data with matching sediment chemistry and sediment toxicity data from elsewhere in the IHAOC, elsewhere in Great Lakes Basin, and/or elsewhere in the United States (EPA 2000). Accordingly, the data in the SedTox database will be accessed and appended to the project database to facilitate the development of the concentration-response models.

Following the development of the concentration-response relationships, the normal range of response rates for amphipods exposed to reference sediment samples will be determined (i.e., following the procedure outlined in MacDonald et al. 2002). First, the distribution of the response data will be evaluated. Next, the response data will be transformed to create a normal distribution and the 2.5th and 97.5th percentile values will be calculated. Following reverse transformation, the 2.5th percentile response value will be used to define the lower limit of the normal range of amphipod responses following exposure to reference sediment samples from the IHAOC. By comparison, the incidence of sediment toxicity for amphipods exposed to reference sediment samples will be determined by calculating the percent of reference samples that are toxic to amphipods.

The risk-based PRGs will be derived for the various COCs and COC mixtures by considering the response rates for amphipods exposed to relatively uncontaminated (i.e., reference) sediment samples. More specifically, the concentrations of COCs that posed a low risk to sediment-dwelling organisms will be determined by calculating the response rate that represents a 10 percent decrease in survival from that for reference samples. Using this approach, sediment samples with amphipod survival rates greater than this value will be considered to pose a low risk to sediment-dwelling organisms. The COC concentrations that correspond to this response rate will be determined using the concentration-response relationships that are established using the matching sediment chemistry and toxicity data. This concentration will be used directly as the preliminary PRG-Intermediate Risk (PRG-IR) for that COC (MacDonald et al. 2003a).

The concentrations of COCs that pose a high risk to sediment-dwelling organisms will be derived using a similar procedure. More specifically, the response rate of amphipods exposed to sediments from the study area that represents a 20 percent decrease in survival from that for amphipods exposed to reference sediment samples will be determined. Using this approach, sediment samples with survival rates of amphipods lower than this value will be considered to pose a high risk to sediment-dwelling organisms. The concentration that corresponds to this response rate will be determined using the concentration-response relationships that were derived using the matching sediment chemistry and toxicity data for each COC and COC mixture. This concentration will be adopted as the preliminary PRG-High Risk (PRG-HR) for the COC and COC mixture (MacDonald et al. 2003a).

The PRGs that are based on the incidence of toxicity to amphipods will be developed using procedures that are consistent with those that are used to derive the PRGs based on magnitude of toxicity (MacDonald et al. 2003a). First, the incidence of toxicity for reference sediment samples will be determined by calculating the proportion of reference samples that are toxic to amphipods in 10-d or 28-d whole-sediment toxicity tests. Then, the incidence to toxicity that corresponded to a 20 percent and 50 percent increase over reference conditions will be determined. Using the corresponding concentration-response models, the concentrations that represent a 20 percent and 50 percent increase over reference conditions will be calculated for each COC and COC mixture, and adopted as the preliminary PRG-IR and preliminary PRG-HR, respectively.

Application of the aforementioned procedures will facilitate the development of two sets of initial PRGs (i.e., based on magnitude of toxicity and incidence of toxicity). Each set of PRGs is intended to establish the concentrations of COCs and COC mixtures that are associated with low (<PRG-IR), intermediate (i.e., moderate; \geq PRG-IR and \leq PRG-HR), and high (>PRG-HR) risks to sediment-dwelling organisms. These PRGs will then be evaluated to determine which would provide the most reliable tools for assessing various remedial alternatives for the WBGCR.

7.0 Evaluation of the Reliability of the Benthic Preliminary Remediation Goals

Two sets of PRGs (i.e., PRGs based on the incidence of toxicity and PRGs based on the magnitude of toxicity) will be derived and considered for selection as the benthic PRGs for the WBGCR. Because the objective of this evaluation is to establish a single set of benthic PRGs that can be used to guide remedial actions within the river, both sets of PRGs will be evaluated to determine which PRGs are most consistent with the RAOs that have been established for the site (i.e., to assess their reliability).

The reliability evaluation of the PRGs will consist of several steps. In the first step of the process, individual sediment samples will be classified into three groups based on the concentration of the selected COC or COC mixture (e.g., total PAH concentrations below the PRG-IR, between the PRG-IR and PRG-HR, and above the PRG-HR). The samples that are classified into the low-risk group based on chemical concentration will be predicted to be not toxic to benthic invertebrates. The accuracy of this prediction will then be evaluated by determining the proportion of samples within the low risk group that actually pose a low risk to benthic invertebrates, based on the results of the whole-sediment toxicity tests with *H. azteca*. A similar procedure will be used to assess the reliability of PRG-HRs.

The criteria for evaluating the reliability of the PRG-IRs have been established on an a priori basis, using the RAOs that have been established for the WBGCR. These criteria will be used to select the PRGs that are most consistent with the sediment management narratives described in the RAOs. More specifically, the PRG-IRs will be considered to be reliable if the incidence to toxicity is <20 percent at concentrations of COCs or COC mixtures below the PRG-IR and if the incidence of toxicity is >50 percent at concentrations of COCs or COC mixtures above the PRG-IR. Therefore, the probability of observing false negative results will be less than 20 percent at COC concentrations below the PRG-IR (i.e., <20 percent of the samples with COC concentrations below the PRG-IR would be toxic). Additionally, the probability of observing false positive results at COC concentrations above the PRG-IR will be less than 50 percent.

The criteria for evaluating the PRG-HRs have also been established using the sediment management narratives articulated in the RAOs. More specifically, the PRG-HRs will be considered to be reliable if the incidence of toxicity is >80 percent at COC concentrations above the PRG-HR and if the incidence of toxicity is <50 percent at COC concentrations between the PRG-IR and the PRG-HR. Therefore, the probability of observing false positive results will be less than 20 percent at concentrations of COCs or COC mixtures above the PRG-HR (i.e., ≥ 80 percent of the samples with concentrations above the PRG-HR will be classified as toxic). Additionally, the probability of observing false negative results will be less than 20 percent at concentrations of COCs or COC mixtures below the PRG-HR. (See Appendix E1 and E2 of MacDonald et al. 2002; MacDonald et al. 2003a for the underlying rationale for these criteria).

8.0 Final Selection of the Benthic Preliminary Remediation Goals

The results of the reliability evaluation will be used to select the PRGs that are most consistent with the sediment management objectives described in the RAOs. More specifically, this evaluation will be undertaken to identify the PRGs that, if applied in the WBGCR, would result in false positive and false negative rates of ≤ 20 percent. Accordingly, the PRGs (PRG-IR and PRG-HR) for each COC and COC mixture that best satisfied these criteria will be identified. If these criteria can be met using a single PRG (i.e., a PRG-IR or PRG-HR), then that PRG will be recommended for the COC or COC mixture because it would simplify the remedial alternatives evaluation process.

References

- ASci Corporation. 2001. Results of Ten-Day *Hyaella azteca* Toxicity Test with Whole Sediment Samples from East Chicago Habitat Enhancement Demonstration. ASci-ETL Study ID #3600-013. Submitted to the U.S. Army Corps of Engineers. Chicago District. Chicago, Illinois.
- ASTM (American Society for Testing and Materials). 2004. Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates. E1706-00. ASTM 2004 Annual Book of Standards Volume 11.05. West Conshohocken, Pennsylvania.
- EPA (U.S. Environmental Protection Agency). 2000. Predictions of Sediment Toxicity Using Consensus-Based Freshwater Sediment Quality Guidelines. EPA 905/R-00-007. Great Lakes National Program Office. U.S. Environmental Protection Agency. Chicago, Illinois.
- FWENC (Foster Wheeler Environmental Corporation). 2002. Field and Laboratory Data Report for the Chemical, Physical, and Toxicological Characterization of Roxana Marsh. Prepared for the U.S. Fish and Wildlife Service by Foster Wheeler Environmental Corporation, Bothell, Washington. September.
- FWENC. 2003. Site Characterization Report, West Branch of the Grand Calumet River, Lake County, Indiana. Prepared for the U.S. Fish and Wildlife Service by Foster Wheeler Environmental Corporation, Bothell, Washington. August.
- Ingersoll, C.G. and D.D. MacDonald. 1999. An Assessment of Sediment Injury in the West Branch of the Grand Calumet River. Volume I. Prepared for Environmental Enforcement Section. Environment and Natural Resources Division. United States Department of Justice. Washington, District of Columbia.

- Ingersoll, C.G., D.D. MacDonald, N. Wang, J.L. Crane, L.J. Field, P.S. Haverland, N.E. Kemble, R. Lindskoog, C. Severn, and D.E. Smorong. 2001. "Predictions of Sediment Toxicity Using Consensus-Based Freshwater Sediment Quality Guidelines." *Archives of Environmental Contamination and Toxicology* 41:8-21.
- Kemble, N.E., C.G. Ingersoll, and C.D. Ivey. 2002. Preliminary Report on the Assessment of the Toxicity of Sediment from West Branch Grand Calumet River to the Amphipod, *Hyalella azteca*. Columbia Environmental Research Center. United States Geological Survey. Columbia, Missouri.
- Lauenstein, G.G. and A.Y. Cantillo. 1993. Sampling and Analytical Methods of the National Status and Trends Program: National Benthic Surveillance and Mussel Watch Projects 1984 to 1992 (Vol. 1), Overview and Summary of Methods. NOAA Technical Memorandum NOS ORCA 71. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Silver Spring, Maryland.
- MacDonald, D.D. and C.G. Ingersoll. 2000. An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan. Prepared for U.S. Fish and Wildlife Service. Bloomington, Indiana.
- MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems." *Archives of Environmental Contamination and Toxicology* 39:20-31.
- MacDonald, D.D., C.G. Ingersoll, D.R.J. Moore, M. Bonnell, R.L. Breton, R.A. Lindskoog, D.B. MacDonald, Y.K. Muirhead, A.V. Pawlitz, D.E. Sims, D.E. Smorong, R.S. Teed, R.P. Thompson, and N. Wang. 2002. Calcasieu Estuary Remedial Investigation/Feasibility Study (RI/FS): Baseline Ecological Risk Assessment (BERA). Technical report plus appendices. Contract No. 68-W5-0022. Prepared for CDM Federal Programs Corporation and U.S. Environmental Protection Agency. Dallas, Texas.
- MacDonald, D.D., D.E. Smorong, R.A. Lindskoog, and C.G. Ingersoll. 2003a. An Assessment of Injury to Human Uses of Fisheries Resources in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan. Prepared for U.S. Fish and Wildlife Service. Bloomington, Indiana.
- MacDonald, D.D., R.L. Breton, K. Edelmann, M.S. Goldberg, C.G. Ingersoll, R.A. Lindskoog, D.B. MacDonald, D.R.J. Moore, A.V. Pawlitz, D.E. Smorong, and R.P. Thompson. 2003b. Development and Evaluation of Preliminary Remediation Goals for Selected Contaminants of Concern at the Calcasieu Estuary Cooperative Site, Lake Charles, Louisiana. Prepared for U.S. Environmental Protection Agency. Dallas, Texas.

APPENDIX C
RESPONSIVENESS SUMMARY
TO
PUBLIC COMMENTS ON THE DRAFT PRELIMINARY PROBLEM
FORMULATION
TECHNICAL MEMORANDUM FOR THE WEST BRANCH OF THE
GRAND CALUMET RIVER
LAKE COUNTY, INDIANA DATED JANUARY 13, 2004

Introduction:

This Responsiveness Summary addresses comments provided on February 6, 2004, by Dr. G. Fred Lee, on behalf of the Sanitary District of Hammond, the only commenter on the Draft Preliminary Problem Formulation Technical Memorandum for the West Branch of the Grand Calumet River. The responses provided recognize the importance of the comments submitted. The document has been significantly revised and, partially based on the comments, re-titled to be more representative of its original intended purpose; that is, to present a summary of the basis and development of preliminary Remedial Action Objectives (RAOs). The new title is: Development of Remedial Action Objectives to Support the Evaluation of Restoration Alternatives for the West Branch of the Grand Calumet River.

This document repeats the comments that were submitted and responds to those comments. Changes made to the document in response to a comment are generally summarized in the response to that comment.

Comment 1: In response to a request from Dr. Michael Unger, District Manager of the Sanitary District of Hammond, Indiana, I have reviewed the Draft Technical Memorandum Preliminary Problem Formulation for restoration of the West Branch of the Grand Calumet River prepared by Tetra Tech for the US Fish and Wildlife Service, dated January 13, 2004. My comments on the technical problems with the US Fish and Wildlife Service's approach for defining constituents that are impairing the beneficial uses of the West Branch of the Grand Calumet River are presented herein.

My experience and expertise, which serve as a foundation for these comments, include a Master of Science in Public Health degree from the University of North Carolina focusing on water quality issues, a PhD from Harvard University in environmental engineering and environmental sciences focusing on aquatic chemistry issues, and 30 years of university graduate-level teaching and research devoted to defining and managing the water quality impacts of chemical contaminants in waters, aquatic sediments and wastes. In addition, while a university professor I was a part-time consultant to governmental agencies and industry in these areas and have been a full-time consultant since 1989 when I retired from university teaching and research. One of the areas of particular emphasis that is pertinent to these comments is my extensive work on properly evaluating the water quality significance of contaminants in aquatic sediments. In addition, I have considerable experience in Superfund site investigation and remediation issues.

Dr. Anne Jones-Lee (my wife) has a bachelors degree in biology from Southern Methodist University and a masters and PhD in environmental sciences from the University of Texas, Dallas. Her PhD dissertation was on evaluating the water quality significance of selected chemicals in aquatic sediments. She has considerable expertise and experience in aquatic life

toxicity testing and evaluation. Dr. Jones-Lee and I have worked together as a team since the 1970s on a variety of water quality issues at several locations in the US and in other countries. Our recent work is available in papers and reports from our website, www.gfredlee.com. Additional information on my qualifications to make these comments is appended.

Dr. Jones-Lee and I became familiar with the water quality problems in the West Branch of the Grand Calumet River (WBGCR) in the mid-1990s through serving as consultants to the Sanitary District of Hammond.

Response: *Comment acknowledged, no response required.*

Comment 2: Restoration Goals for the WBGCR

Tetra Tech (Tt) on behalf of the US Fish and Wildlife Service (USFWS) has stated that the goal of the Grand Calumet River Restoration Foundation (GCRRF) Council is

“... to address the effects of sediment contamination in the WBGCR, specifically for the purpose of addressing and correcting environmental contamination in the area of concern, including the cleanup of contaminated sediments in GCR, and the remediation and restoration of natural resource damages within the area of concern.”

This draft Preliminary Problem Formulation (PPF) report is to set the stage for accomplishing these objectives through establishing an approach for identifying the chemicals of concern for public health and environmental impacts (water quality). Based on my over 40 years of work on chemicals in wastewaters and wastes in the environment with respect to determining the sources of potential pollutants, their environmental fate, and impacts on public health and aquatic life, and to developing technically valid, cost-effective management programs, **I find the draft PPF proposed approach falls short of providing a reliable approach for formulating a technically valid, cost-effective water quality problem definition and a framework for management of real significant public health and environment impairments caused by chemicals in the sediments of the WBGCR.**

Response: *The technical memorandum has been revised and re-titled to clarify its purpose; that is, to present a summary of the basis and development of preliminary Remedial Action Objectives. Moreover, the PPF approach has been applied at other sites of interest including the Calcasieu Estuary in Louisiana (MacDonald and Ingersoll 2004).*

Comment 3: A review of the existing water quality characteristic data shows that the West Branch of the Grand Calumet River contains a variety of chemicals that are potential pollutants that could

- cause aquatic life toxicity
- be bioaccumulating to excessive levels in edible organisms
- represent a threat to human health through body contact with the sediments.

Most importantly, the existing database also shows that there is aquatic life toxicity in the WBGCR sediments and that edible aquatic organisms collected from this area contain sufficient concentrations of hazardous chemicals to be a threat to those who use these organisms as food. However, the sediment toxicity data that are available thus far do not distinguish between naturally occurring sediment toxicity associated with eutrophic waterbodies and the toxicity due to anthropogenic inputs of chemicals that in the WBGCR are in toxic/available forms and thereby are causing significant adverse impacts on the numbers and types of desirable forms of aquatic life in the WBGCR. Further, it is not clear from the data available that the chemicals in the WBGCR sediments are the exclusive source of the chemicals that are bioaccumulating to excessive levels in edible organisms taken from the WBGCR.

***Response:** The toxicity of anthropogenic chemicals in sediments of the WBGCR has been established (Ingersoll and MacDonald 1999, Ingersoll et al. 2002, MacDonald et al. 2002a,b). Specifically, the influence of ammonia, grain size, and total organic carbon in the sediment could not explain the severe toxicity observed in sediments evaluated from the WBGCR. Comparisons to results of spiked sediment toxicity test and to pore-water effect concentrations indicate that the anthropogenic chemicals in sediments of the WBGCR are causing or substantially contributing to the observed sediment toxicity. While the document did not imply that sediments were “exclusive source” of chemicals accumulating in biota, they are certainly a very significant source if not the most significant source.*

Comment 4: The approach that the US Fish and Wildlife Service has adopted for addressing the Natural Resources Damage Assessment (NRDA) issues in the West Branch of the Grand Calumet River is not technically valid, from several perspectives. Foster Wheeler (2002) has provided a summary discussion of NRDA restoration issues, where the emphasis is on restoration of degraded aquatic ecosystems to their full beneficial use potential. As quoted above, the GCRRF Council has stated that their goal is restoration of the degraded WBGCR ecosystem. **The current US Fish and Wildlife Service approach for restoration of the West Branch of the Grand Calumet River could result in expenditures of many millions of dollars, yet fail to restore the West Branch of the Grand Calumet River to a healthy ecosystem.** The basic problem is that there are several major current sources of pollutants which, until they are controlled, will almost certainly continue to add constituents that can cause the WBGCR sediments after restoration to still be toxic to aquatic life and still be a source of bioaccumulatable chemicals that would be a threat to human health through body contact and through bioaccumulation in the food web to edible organisms.

***Response:** The approach outlined in the revised approach is not “adopted by the US Fish and Wildlife Service for addressing Natural Resource Damage Assessment (NRDA) issues in the West Branch. . .” The approach adopted represents that approved by all Grand Calumet River*

Restoration Fund Council Agencies (please refer to introduction to the document for a complete listing of these Agencies) and is adopted to comply with the Court-Ordered settlement of Clean Water Act and Natural Resource Damages in the West Branch Grand Calumet River. This approach has been adopted to address contaminated sediments and natural resource injuries associated with those contaminated sediments. The commenter assumes throughout the comments that the approach proposed herein is solely that of the US Fish and Wildlife Service. This is simply an incorrect assumption on the part of the commenter. The GCRRF Council agrees that ongoing sources of contaminants to the WBGCR could impact sediments after restoration. The issues of source control are being addressed by agencies other than the GCRRF Council (e.g., EPA, IDEM, Sanitary District of Hammond). Prior to implementation of any restoration alternatives, the GCRRF Council will endeavor to coordinate remedial activities within the WBGCR to minimize the potential for recontamination of remediated sediments. It is the goal of the GCRRF Council to ensure that ongoing sources of contamination (e.g., CSOs, NIPSCO Coal Gasification Plant) are effectively addressed as part of this coordination effort. The other principal sources of contamination that are now known to exist that require source control are the site of the former manufactured gas plant (MGP) located on the south bank of the Grand Calumet River west of Hohman Avenue in Hammond, and the Columbia Avenue, Sohl Avenue and Johnson Avenue combined sewer overflows.

Comment 5: Failure to Define Current Sources of Aquatic Ecosystem Stressors to the WBGCR

The US Fish and Wildlife Service has approached the NRDA from an overly simplistic approach. The approach is similar to one that would be used if a train car load of a hazardous chemical had been spilled into a high-value trout stream, where the chemicals in the tank car that spilled were highly toxic to fish and were also persistent and accumulated in sediments. As a result there would be need to develop sediment remediation approaches to restore this aquatic ecosystem to its full beneficial uses. This is not the system that exists in the WBGCR. The WBGCR has a variety of potential stressors – some of which have been measured, and some of which have not – that can cause aquatic life toxicity and be adverse to the beneficial uses of this waterbody. Many of the stressors are likely present in current discharges. Until the constituents responsible for the aquatic life toxicity are properly defined through toxicity investigation evaluations (TIEs), their sources identified, and their aqueous environmental chemistry, fate and transport are understood, the potential for achieving the desired goals for the restoration of the WBGCR is questionable.

Response: *The GCRRF Council (not just the US Fish and Wildlife Service as indicated by the commenter), is well aware of the complexities of the potential stressors to the WBGCR. See Response to Comment 4 above. While the WBGCR will never have conditions that would support a trout fishery, the WBGCR has the potential to be a highly valued urban water resource. However, the GCRRF Council is not aware of any current discharges which have been shown to*

be discharging toxics in toxic amounts. Also, see Response to Comment 10, 11, 12, and 24 regarding TIE's.

Comment 6: One of the primary issues of concern with respect to restoring the WBGCR is the current inputs of combined sewer overflows (CSOs) which are adding raw sewage and sewage sludge to the WBGCR. In addition, there is urban, industrial and undeveloped area stormwater runoff that is contributing a variety of chemical constituents that are potential pollutants to the WBGCR.

Response: *The CSOs owned and operated by the Sanitary District of Hammond are under a schedule in a federal court order to be eliminated by 2009. The GCRRF Council has no information that there are point sources of urban, industrial and undeveloped area storm water runoff besides the CSOs that are contributing a variety of chemical constituents that are potential pollutants to the WBGCR.*

Comment 7: Another potentially significant source that is not included in the PPF is groundwater input of pollutants. Groundwater inputs of pollutants are being ignored in this document. Even without the combined sewer overflows and urban and industrial stormwater runoff, there can be groundwater inputs of pollutants that could negate any significant restoration of the WBGCR natural resources. While mention was made at several locations in the PPF about inputs from landfills to the WBGCR, there is no quantitative information presented to evaluate the significance of this source. The potential for groundwaters/landfills to provide hazardous and deleterious chemicals to the WBGCR is a highly significant information gap that must be evaluated in any credible NRDA preliminary problem formulation.

Response: *There are no known landfills that provide contaminated groundwater input to the WBGCR. The GCRRF Council is aware of 2 sources of groundwater inputs of pollutants to the WBGCR. The first is from the former MGP site in Hammond located west of Hohman Avenue on the south bank. With respect to that site, IDEM has received a proposal from NIPSCO to control the source of pollutants under its Voluntary Remediation Program (VRP). IDEM has commented on the proposal and NIPSCO is conducting additional field studies prior to preparing a revised proposal. The other known site is a potential source of non-aqueous phase liquids located in the vicinity of Turner Park in Hammond, which is located east of Sohl Avenue. Groundwater monitoring wells have been installed to assess the significance of that source and a report is under preparation by EPA.*

Comment 8: There is another unregulated source of chemicals that could be potentially adverse to aquatic life in the WBGCR. These are the PPCPs (pharmaceuticals and personal care products) that are discharged to the WBGCR through the Hammond and other sanitary districts' wastewater discharges and combined sewer overflows. There is increasing concern in the water quality management field about pharmaceuticals and personal care products that are legally

discharged to domestic wastewaters, which are known to pass through domestic wastewater treatment plants such as the Hammond Sanitary District treatment plant and can be adverse to aquatic life in the receiving waters. The US EPA has established a PPCP program (<http://www.epa.gov/nerlesd1/chemistry/ppcp/greenpharmacy.htm>) which presents information on the potential ramifications of PPCPs present in domestic wastewaters and other sources, which are passing through conventional wastewater treatment plants into the environment and which cause adverse impacts to aquatic resources. This is yet another source of chemicals that could lead to aquatic life toxicity, altered aquatic organism populations, etc., which would essentially negate restoration of the WBGCR to a fully functioning, uninhibited aquatic habitat. Recently I attended a California Bay-Delta Authority Contaminant Stressor workshop at which a series of lectures on contaminant stressors in the environment were presented. Dr. Tracy Collier, of the NOAA Northwest Fisheries Science Center, discussed in his presentation, "Emerging Issues in Estuarine Toxicology: Reproductive and Developmental Effects," that it is being found that the city of Seattle's combined sewer overflows are likely the source of stressors to aquatic ecosystems that are potentially significantly adverse to parts of the Puget Sound ecosystem near Seattle.

At the Contaminant Stressor workshop, Dr. Christian Daughton of the US EPA National Exposure Research Laboratory, who is the head of the PPCP program, provided a discussion of this issue, "Ubiquitous Pollution from Health and Cosmetic Care: Significance, Concern, Solutions, Stewardship." I have obtained an electronic copy of his PowerPoint slides, which summarize key PPCP issues that are pertinent to attempts to restore the WBGCR ecosystem. I can make these slides available to anyone interested. They provide information on the potential significance of the presence of these chemicals in wastewaters and stormwater runoff.

Response: *Conventional anthropogenic chemicals such as PCBs, PAHs, and metals have been demonstrated to be causes or substantially contributing to the severe toxicity in the WBGCR. The RAOs were developed to address these anthropogenic chemicals that are present in sediment at concentrations 100 to 1000 fold above sediment quality guidelines (MacDonald et al. 2000). The GCRRF Council agrees that research is ongoing that shows that PPCPs may be an emerging environmental issue. However, if PPCPs are later shown to be an issue in the WBGCR, and water quality criteria have been developed by US EPA and/or IDEM, they would be addressed by IDEM through NPDES modification procedures, and are not a part of this project.*

Comment 9: An important issue that has to be considered in developing a restoration program is that the WBGCR at times consists almost entirely of domestic wastewaters. At times there are very few other sources of flow through the WBGCR. At these times this system is more akin to being a sewage lagoon than an aquatic ecosystem. The restoration of this system may not be

possible without massive expenditures for control of the CSOs and all stormwater runoff, and very high degrees of advanced domestic wastewater treatment, far beyond anything practiced anywhere in the world. Even then, normal runoff from wetland areas along the WBGCR at times could introduce enough natural pollutants to lead to highly degraded water quality. Those who are familiar with wetlands water quality impacts know that wetlands, such as along and near the WBGCR, are at times significant sources of natural pollutants. Under conditions where there is little or no water in the WBGCR to dilute these constituents, the system could have highly degraded water quality and may never, even without CSOs, stormwater runoff and highly treated domestic wastewater inputs, achieve its full potential for designated aquatic-life-related beneficial uses. It is my understanding that the Sanitary District of Hammond is at its limit of borrowing capacity and is not in a position to acquire funds to control the CSOs or to provide ultra-high degrees of treatment of its domestic wastewater effluent and stormwater runoff.

Dredging and/or capping of WBGCR sediments may have little or no impact on the natural resources in the WBGCR that could be occurring if there were no combined sewer overflows or stormwater runoff to this waterbody. Without proper evaluation of current sources, the proposed restoration approaches could represent a massive waste of public and private funds in an ill-defined, improperly investigated NRDA.

Response: *The evaluation of restoration alternatives will consider the highly modified hydrology of the WBGCR. This information will be incorporated into the development of the RAOs, which may not include the attainment of “its full potential for aquatic-life-related beneficial uses”. While the WBGCR will never have conditions that would support a trout fishery, the WBGCR has the potential to be a highly valued urban water resource. In addition, and as discussed above, the GCRRF Council is coordinating with the responsible agencies to address the on-going potential sources of contaminants to the WBGCR, including the Sanitary District of Hammond.*

Comment 10: Unreliable Designation of Constituents Responsible for Toxicity

The most significant problem with the Tt/USFWS proposed approach is that the proposed water quality problem identification largely ignores the aqueous environmental chemistry of the potential pollutants. Many of the WBGCR sediment-associated chemicals listed in the PPF as chemicals that need to be remediated have complex aquatic chemistry, where substantial parts of the total concentration in a sediment is non-toxic/non-available. The chemical concentration-based approach for water quality problem identification used by Tt/USFWS is well known to be technically invalid and can readily misidentify chemicals in sediments as a cause of toxicity.

The US Fish and Wildlife Service has unfortunately followed unreliable approaches for designating constituents of concern that are responsible for the aquatic life toxicity in the WBGCR sediments. The approach of trying to use total concentrations of contaminants present

relative to the co-occurrence-based so-called guidelines, such as the D. D. MacDonald PECs, is well known to be technically invalid and highly unreliable in predicting the cause of aquatic life toxicity. Those of us with aquatic chemistry and aquatic toxicology expertise and experience, who work in the sediment quality evaluation field, have known since the early 1970s that total concentrations of a chemical, such as used in the D. D. MacDonald PEC values, are unreliable for predicting water quality impacts due to specific constituents in a system where there are potentially multiple stressors. While the fundamentally flawed nature of co-occurrence-based sediment quality guidelines has been understood since they were first developed by Long and Morgan, and subsequently by D. D. MacDonald in the early 1990s, by those who understand aquatic chemistry, aquatic toxicology and water quality issues, there is growing recognition by many experts in the field who understand these issues about the unreliability of the co-occurrence-based D. D. MacDonald PEC approach for defining the causes of toxicity in aquatic sediments.

In October 2002 the Aquatic Ecosystems Health and Management Society held an international conference in Chicago (Fifth International Symposium on Sediment Quality Assessment – SQA5) where these issues were discussed in detail. A number of the world's recognized experts on sediment quality evaluation unanimously agreed about the unreliability of the co-occurrence-based sediment quality guidelines. As Dr. Dominic DiToro, now a distinguished professor at the University of Delaware, pointed out, to the extent that these co-occurrence-based guidelines appear to have any predictive capability, it is purely a coincidence. Dr. Tom O'Connor of NOAA has indicated that, based on his review of existing databases, this approach can be wrong in predicting toxicity more times than it is right – i.e., flipping a coin would give a more correct answer on whether sediments are toxic than using the co-occurrence-based sediment quality guidelines used by the US Fish and Wildlife Service.

Response: *The GCRRF Council strongly disagrees with the commenter about the validity of using sediment quality guidelines to assess sediment toxicity to benthic invertebrates. The commenter provided no data or analyses demonstrating that SQGs or the PEC approach are not reliable. Importantly, the PEC approach has been extensively described and applied to accurately predict toxicity in sediments from across North America as has been described in numerous peer-reviewed journal articles in the scientific literature (e.g., Ingersoll et al. 1996, 2001; 2002; MacDonald et al. 2000, 2002a,b; USEPA 1996, 2000). Importantly, the commenter has not provided a single peer-reviewed journal article in the scientific literature supporting his opinion that the SQG or PEC approach is not reliable. Given the number of guidelines available, selection of any one as the most appropriate and most reliable for ability to predict toxicity and impacts to benthic species at a study site is challenging. Each guideline set was generally developed using a different methodology (e.g. Ontario [Persaud et al. 1993] used the screening level concentration approach and Ingersoll et al.[1996a] used the effect level approach). Each*

approach for developing guidelines has inherent advantages, limitations, levels of acceptance, different extent of field validation, and differing degree of environmental applicability (USEPA 1992, Wenning et al. 2005). Selecting one set of guidelines is further complicated by uncertainties regarding the bioavailability of contaminants in sediments, the effects of co-varying chemicals and chemical mixtures, the ecological relevance of the guidelines, and correlative versus causal relations between chemistry and biological effects (MacDonald et al. 2000a). Given these challenges much discussion has taken place over the use of guidelines as a tool for use in doing sediment quality assessments (Peddicord et al. 1998, Wenning et al. 2005). Cautions are often placed on the use of any one set of guidelines as stand alone decision tools in the assessment and remediation decision making process without additional supporting data from toxicity testing and in-field studies. However, recent evaluations based on combining several sets of guidelines into one to yield "consensus-based" guidelines have shown that such guidelines can substantially increase the reliability, predictive ability, and level of confidence in using and applying the guidelines (Swartz 1999; Crane et al. 2000; MacDonald et al. 2000 a, 2000 b; Ingersoll et al. 2001, USEPA 2000). The agreement of guidelines derived from a variety of theoretical and empirical approaches helps to establish the validity of the consensus-based values. Use of values from multiple guidelines that are similar for a contaminant provides a weight-of-evidence for relating to actual biological effects (Wenning et al. 2005).

A series of papers were described in the peer-reviewed scientific literature (Swartz, 1999; MacDonald et al. 2000a, 2000b;) that addressed the difficulties associated with the assessment of sediment quality conditions using various individual numerical sediment quality guidelines. The results of these investigations demonstrated that combining and integrating the effect levels from several sets of guidelines to result in consensus-based sediment quality guidelines provide a unifying synthesis of the existing guidelines, reflect causal rather than correlative effects, and can account for the effects of contaminant mixtures in sediment (Swartz, 1999). Additionally, MacDonald et al. (2000a), USEPA (2000), and Ingersoll et al. (2001) have evaluated the consensus-based sediment effect concentrations for reliability in predicting toxicity in sediments by using matching sediment chemistry and toxicity data from field studies conducted throughout the United States. The results of their evaluations showed that most of the consensus-based threshold effect concentrations (TEC - lower effect level) and probable effect concentrations (PEC - upper effect level) for individual contaminants provide an accurate basis for predicting the absence or presence, respectively, of sediment toxicity.

Ingersoll et al. (2001), USEPA (2000), MacDonald et al. (2000a), Long and MacDonald (1998), and Fairey et al. (2001) further evaluated the reliability of SQG quotients to predict the toxicity of mixtures of different contaminants in sediments. For example, mean PEC quotients were calculated to evaluate the combined effects of multiple contaminants in sediments (Ingersoll et al. 2001; MacDonald et al. 2000a; USEPA 2000). A PEC quotient is calculated for each

contaminant in each sample by dividing the concentration of a contaminant in sediment by the PEC concentration for that chemical. A mean quotient is calculated for each sample by summing the individual quotient for each contaminant and then dividing this sum by the number of PECs evaluated. Dividing by the number of PEC quotients normalizes the value to provide comparable indices of contamination among samples for which different numbers of contaminants were analyzed. Results of the evaluation showed that the mean PEC quotients that represent mixtures of contaminants were highly correlated to the incidences of toxicity in the same sediments.

Barrick et al. (1988), Long et al. (1995); and USEPA (1996, 2000) evaluated the predictive ability of empirically-derived SQGs based on dry weight or organic carbon normalization, and found dry-weight normalized quotients to be as predictive of sediment toxicity compared to organic carbon normalization. Similarly, Long et al. (1998) reported that SQGs for metals normalized to dry weight were as predictive to SQGs normalized to SEM-AVS concentrations. Additionally, measures of pore-water chemistry and pore-water toxicity identified specific chemicals that are contributing directly to the observed toxicity. Word et al. (2005) concluded that if the sediment that is being evaluated has an organic carbon concentration substantially above these mean concentrations used to establish SQGs (e.g., >8% for freshwater sediment or >4% for marine sediment), then the organic-carbon normalized empirical SQGs should be considered. Word et al. (2005) recommended that additional analyses should be performed to determine if normalization to organic carbon improves the predictive ability of empirical SQGs. Comparisons were made for WBGCR sediment that were either dry-weight normalized or were organic carbon normalized for PAHs or PCBs or were SEM-AVS normalized for metals. Results of these analyses indicated that concentrations in sediment dry-weight normalized SQGs were as predictive of sediment toxicity in the WBGCR compared to concentrations in sediment normalized to TOC or SEM-AVS (MacDonald et al. 2005).

Based on MacDonald et al. (2000a), the consensus-based SQGs can be used for or considered for the following:

- To provide a reliable basis for assessing sediment quality conditions in freshwater ecosystems.*
- To identify hot spots with respect to sediment contamination.*
- To determine the potential for and spatial extent of injury to sediment-dwelling organisms.*
- To evaluate the need for sediment remediation.*
- To support the development of monitoring programs to further assess the extent of contamination and the effects of contaminated sediment on sediment-dwelling organisms.*

The above applications are strengthened when the consensus-based values are used in combination with other sediment quality assessment tools including effects-based testing (i.e., sediment toxicity tests, bioaccumulation assessments, benthic invertebrate community assessments, and more comprehensive designed risk-based studies).

Finally, the Society of Environmental Toxicology and Chemistry recently held a workshop designed to specifically develop guidance on the use of sediment quality guidelines and related tools for the assessment of contaminated sediments (Wenning et al. 2005). Importantly, this workshop invited about 50 international experts to discuss appropriate uses of sediment quality guides. This group of experts included Jack Word, Barbara Albrecht, Renaldo Baudo, Steve Bay, Dominic Di Toro, Jeff Hyland, Chris Ingersoll, Peter Landrum, Edward Long, Jim Meador, David Moore, Tom O'Connor, and Jim Shine. Specifically, these individual scientists were tasked with developing recommendations on use of sediment quality guidelines for assessing sediment toxicity (Word et al. 2005). The following is a summary of some of the conclusions from this workshop regarding the utility of applying SQGs in the assessment of sediment toxicology. In advance of the workshop, a data base of published laboratory and field studies in freshwater, estuarine, and marine environments encompassing more than 8000 sediment samples was assembled and evaluated. It was determined that for these samples, empirical effects-based SQGs including PECs can be used to assess the probability of observing effects with known statistical levels of confidence. Among the different empirical SQG approaches, the incidence of effects, or the degree of the response, increases with increasing sediment contamination. Among all of the sediment toxicity data sets examined, the lowest incidence of adverse biological effects (less than about 10% of the samples) was identified at contaminant concentrations less than the low range of empirically-derived SQGs (i.e., below a mean quotient of about 0.1); the highest incidence of toxicity (greater than about 75%) was observed at contaminant concentrations above the upper range of empirical SQGs (i.e., above a mean quotient of about 1.5 to 2.3). The quantitative extent to which chemically based numeric SQGs are predictive of the presence, or absence, of toxicity to sediment-dwelling organisms or to higher trophic level organisms is a critical concern among scientists and agencies evaluating the application of one or more numeric SQG approaches in assessments of sediment quality. Empirical SQGs for total PAH and total PCBs are similar to comparable guidelines derived using theoretical equilibrium partitioning approaches. This concordance suggests that these mixtures may be causally implicated in the toxicity observed in a substantial number of sediments. Importantly for both laboratory toxicity tests and benthic community studies, an incremental increase in effects has frequently been observed with an incremental increase in contamination as defined by different SQG approaches. However, direct measurement of toxicity in the laboratory and/or benthic community impacts in the field is required to determine if an individual sample with moderate contamination is toxic or nontoxic. Importantly, Wenning et al. (2005) recommend a weight-of-

evidence approach integrating measures of sediment chemistry, sediment toxicity, and benthic community impacts in the evaluation of SQGs. This is what has specifically been done to establish the PRGs for the WBGCR (Ingersoll et al. 1996, 2001, 2002; MacDonald et al. 2000, 2002a,b; USEPA 1996, 2000).

Comment 11A: In December 2002, for the California State Water Resources Control Board and the Central Valley Regional Water Quality Control Board, Dr. Anne Jones-Lee (my wife) and I prepared a comprehensive report which included a section on why co-occurrence-based sediment quality guidelines are unreliable for any purpose. A copy of our review of this topic is available from our website:

Lee, G. F. and Jones-Lee, A., “Unreliability of Sediment Co-Occurrence-Based Approaches for Evaluating Aquatic Sediment Quality,” Excerpts from Lee, G. F. and Jones-Lee, A., “Organochlorine Pesticide, PCB and Dioxin/Furan Excessive Bioaccumulation Management Guidance,” California Water Institute Report TP 02-06 to the California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 170 pp, California State University Fresno, Fresno, CA, December (2002). <http://www.gfredlee.com/UnrelSedCooccur.pdf>

Response: *The internal report posted on the commenter’s web site presents no data or data analyses to support the opinion of the commenter that empirically-derived SQGs are unreliable for any purpose. Moreover, the response to Comment 10 provides a summary of a recently completed SETAC workshop that contradicts the opinion of the commenter (Wenning et al. 2005, Word et al. 2005).*

Comment 11B: In addition to Dr. Dominic DiToro, individuals such as Dr. Allen Burton and Dr. Peter Chapman, in keynote presentations at the Sediment Quality Assessment (SQA5) symposium, discussed the unreliability and inappropriateness of using total concentration-based sediment guidelines for any purpose. As we have discussed in our review, in order to determine whether sediments are toxic, toxicity should be measured using a suite of sensitive organisms. In order to determine the cause of this toxicity, sediment toxicity investigation evaluations (TIEs) **must** be conducted. There is no shortcut to this approach. I presented a paper at SQA5 on the use of chemical information in a weight of evidence evaluation of sediment quality. A copy of our paper is available on our website:

Lee, G. F. and Jones-Lee, A., “Appropriate Incorporation of Chemical Information in a Best Professional Judgment ‘Triad’ Weight of Evidence Evaluation of Sediment Quality,” Presented at the Fifth International Symposium on Sediment Quality Assessment (SQA5), “Aquatic Ecosystems and Public Health: Linking Chemical, Nutrient, Habitat and Pathogen Issues,” Aquatic Ecosystems Health and Management Society, Burlington, Ontario, Canada (2003). (In press.)

<http://www.gfredlee.com/BPJWOEpaper.pdf>

The proceedings of this conference are in press and should be available in the near future.

Response: *Chris Ingersoll and Don MacDonald have worked closely with Dominic Di Toro, Allen Burton, and Peter Chapman over the past 20 years. Each of these individuals has advocated the use of multiple lines of evidence in the assessment of sediment toxicity. The commenter also recommends the use of multiple lines of evidence to assess sediment quality including the use of toxicity tests with sensitive organisms. The PECs used to establish the PRGs for the WBGCR have been extensively evaluated using site-specific multiple lines of evidence. Specifically, measures of sediment chemistry, benthic community structure, and laboratory sediment toxicity have been evaluated in the WBGCR (Ingersoll and MacDonald 1999, Ingersoll et al. 2001, 2002; USEPA 1996, 2000). Importantly, toxicity tests have been conducted with sensitive organisms (e.g., *Hyalella azteca*, *Chironomus tentans*) using standard methods outlined in ASTM (2005) and in USEPA (2000). Measures of whole-sediment chemistry, pore-water chemistry, whole-sediment toxicity, pore-water toxicity, benthic community structure, and bioaccumulation evaluations were all integrated in a weight-of-evidence approach, as advocated by the commenter. Results of this weight-of-evidence assessment of sediment toxicity in the WBGCR indicated that the PECs are highly reliable and can accurately predict both the presence and absence of sediment toxicity. The commenter advocates use of toxicity identification evaluation (TIEs) procedures. Unfortunately, no standard methods have been published on for the use of TIEs in the assessment of sediment toxicity. Only a limited number of TIEs have been attempted for sediment in acute tests (e.g., 2- to 10-day toxicity tests in pore water) rather than in chronic tests. Importantly, TIE methods lack the specificity needed to identify the specific chemicals that are causing toxicity to sediment-dwelling organisms (Word et al. 2005). Specifically, TIEs that have been attempted with sediment have not been proven to provide sufficient cause and effect relationships between sediment toxicity and the individual chemicals of concern in sediment (Ingersoll et al. 1997). However, the GCRRF Council's mandate is to "address the effects of sediment contamination in the WBGCR specifically for the purpose of addressing and correcting environmental contamination in the area of concern, including the cleanup of contaminated sediments in GCR, and the remediation and restoration of natural resource damages". As discussed above, the identification of specific causes of toxicity are not as much of a concern as eliminating as much exposure as possible to contaminated sediments that have been shown to cause aquatic life toxicity.*

Comment 12: Page 1-3 of the PPF, in section 1.2.1 Ecological Impacts, states,

"Several investigations have been conducted to assess the effects on ecological receptors associated with exposure to chemicals of potential ecological concern (COPECs) in the WBGCR. For example, Ingersoll and MacDonald (1999) conducted an assessment of

sediment injury in the WBGCR. The results of this investigation demonstrated that the concentrations of sediment-associated COPECs in the WBGCR were sufficient to injure sediment-dwelling organisms.”

Those who understand aquatic chemistry and aquatic toxicology know that such statements can readily be in error with respect to defining the cause of sediment toxicity. It has been known since the early 1970s that it is not possible to relate concentrations directly to impacts. While individuals like Long and Morgan and D. D. MacDonald claim that they can do this, their claims are without technical merit. It is pure coincidence if a particular set of data that they use happen to show a relationship. It should not be interpreted to mean cause and effect. As discussed in our review and as is obvious, the toxicity that is found in sediments could readily be due to a variety of chemical constituents acting alone or in combination with other chemicals to cause toxicity. The only reliable way to assess cause and effect is through TIEs.

Response: *See response to Comments 10 and 11. As discussed above, the identification of specific causes of toxicity are not as much of a concern as eliminating as much exposure as possible to contaminated sediments that have been demonstrated to cause aquatic life toxicity. Furthermore, TIEs lack the specificity for identifying specific chemicals of interest in sediment; the methods are not standardized, and have only been attempted using acute, not chronic methods.*

Comment 13: On page 1-3, the last sentence states, “Fish populations were also reduced in the WBGCR, due to the loss or degradation of habitat associated with inputs of sewage sludge and other substances.” Since sewage sludge continues to be added to the WBGCR associated with CSOs, problems due to sewage sludge in the past will continue, even though many millions of dollars may be spent removing the existing deposits.

Response: *The GCRRF remedial plan is being prepared in anticipation that the Sanitary District of Hammond will comply with its court-ordered schedule to eliminate the 3 CSOs in the West Branch by 2009.*

Comment 14: On the bottom of page 1-3 and top of page 1-4, a number of chemicals are listed that have been identified as substances that are causing or substantially contributing to sediment injury in the WBGCR. That analysis is based on the fundamentally flawed approach of finding a contaminant in sediments and assuming that there is a relationship between its presence and an adverse impact. As just one example, one of the constituents listed is total organic carbon. Total organic carbon typically is a detoxifying agent – not a toxicant.

Response: *TOC is not listed as a toxicant, it is however a COPC given that excess TOC can have adverse effects on water quality (e.g., DO, ammonia) or on sediment texture (e.g., smothering of benthic invertebrates or fish).*

Comment 15: The statement is made on page 1-4, second paragraph, that, *“In addition, the results of toxicity tests confirmed that whole sediments, pore water, and/or elutriates were toxic to aquatic organisms.”* As we and others discuss, sediment tests are reliable for assessing toxicity, while chemical concentrations are not. Those who understand aquatic chemistry in sediments know that many of the chemicals listed in the first paragraph on page 1-4 exist in a variety of chemical forms, only some of which are toxic. It is inappropriate to conclude that those chemicals listed in the first paragraph of page 1-4 are responsible for toxicity without doing the TIE work to demonstrate that the toxicity is caused by one or more of these chemicals. Further, there could readily be other chemicals in the sediments that are the primary cause of toxicity, which are not on the D. D. MacDonald PEC list. Without identifying the chemicals responsible for toxicity through reliable approaches and determining whether they are still being input to the WBGCR, it is readily possible that large amounts of public and private funds could be spent removing or controlling sediment-associated constituents only to find that there is no real change in the WBGCR ecosystem characteristics/beneficial uses. It is almost certain that the sediments will still be toxic after restoration.

Response: See response to Comments 10 and 11. As discussed above, the GCRRF Council is coordinating with the responsible agencies to address the on-going potential sources of contaminants to the WBGCR.

Comment 16: Page 1-5, section 1.3 Purpose and Scope of Technical Memorandum states,

“The purpose of the WBGCR Phase III activities are [sic] to provide the GCRRF Council with specialized technical support for identifying and evaluating remedial restoration alternatives for the West Branch of the Grand Calumet River, IN and to conduct a focused baseline human health risk assessment for this area. More specifically, this technical memorandum centers on establishing preliminary Conceptual Site Models (CSM) for both ecological and human health receptors and the development of preliminary Remedial Action Objectives (RAOs).”

That purpose needs to be significantly expanded, and preceded by properly conducted studies by knowledgeable individuals who incorporate aquatic chemistry and aquatic toxicology into evaluating the cause of the toxicity, the source(s) of the toxicant(s) responsible, whether these toxicants are still being added to the WBGCR from combined sewer overflows, stormwater runoff, runoff from nearby lands, domestic wastewater discharges, discharges of PPCPs, etc. With the additional information it then should be possible to make an assessment of whether any funds should be spent in attempting to remediate sediments in the WBGCR until such time as the sources of the constituents responsible are under control.

Response: The document has been revised to reflect the main purpose of developing preliminary RAOs. The document also provides a roadmap of how the BHHRA will be conducted and the

basis for the GCRRF Council's decision to focus on development of benthic/sediment PRGs. The GCRRF Council will endeavor to coordinate remedial activities within the WBGCR to minimize the potential for recontamination of remediated sediments. It is the goal of the GCRRF Council to ensure that ongoing sources of contamination (e.g., CSOs, former MGP) are effectively addressed as part of this coordination effort.

Comment 17: On page 1-6, the first full paragraph, mid-paragraph states,

"The findings from these risk assessments will be considered together to develop and compare ecological and human health PRGs. This will allow for risk management decision makers to select the most appropriate restoration alternatives. Successful completion of this project involves a cooperative effort between the risk managers (i.e., GCRRF Council), and the human health and ecological risk assessors."

This statement is significantly deficient in not including an assessment of the sources of constituents that will continue to be added to the WBGCR.

Response: *This section has been revised to avoid the implication that an ecological risk assessment is being performed. In addition, the GCRRF Council's coordination efforts with other agencies responsible for source control have been expanded.*

Comment 18: Appendix A presents a Baseline Human Health Risk and Analysis Plan, while Appendix B presents an Analysis Plan for Development of Ecological Risk-Based Preliminary Remediation Goals. These appendices provide the overall approach that is proposed to assess the risk of contaminants in the WBGCR.

On page A-1, in the second paragraph is a list of the requirements of applicable regulatory and other guidance documents for conducting a baseline human health risk assessment. The approach that is proposed follows conventional Superfund methodology. The component of this that is missing, which could become very important in a proper risk assessment, is an assessment of the bioavailability of constituents in the sediments. While the conventional Superfund approach assumes that all measured concentrations represent toxic available forms, it is well established that, for many constituents – and this would be especially true for contaminated sediments, such as in the WBGCR – the contaminants are bound to the sediment matrix in such a way as to be not available to cause toxicity or uptake, either through contact by humans or through the food web.

Response: *The uncertainties associated with the Superfund methodology will be discussed as part of the BHHRA. Barrick et al. (1988), Long et al. (1995); and USEPA (1996, 2000) evaluated the predictive ability of empirically-derived SQGs based on dry weight or organic carbon normalization and found dry-weight normalized quotients to be as predictive of sediment toxicity compared to organic carbon normalization. Similarly, Long et al. (1998) reported that*

SQGs for metals normalized to dry weight were as predictive to SQGs normalized to SEM-AVS concentrations. Additionally, measures of pore-water chemistry and pore-water toxicity can be used to identify specific chemicals that are contributing directly to the observed toxicity. Word et al. (2005) conclude that if the sediment that is being evaluated has an organic carbon concentration substantially above these mean concentrations used to establish SQGs (e.g., >8% for freshwater sediment or >4% for marine sediment), then the organic-carbon normalized empirical SQGs should be considered. Word et al. (2005) recommended that additional analyses should be performed to determine if normalization to organic carbon improves the predictive ability of empirical SQGs. Comparisons were made for WBGCR sediment that were either dry-weight normalized or were organic carbon normalized for PAHs or PCBs or were SEM-AVS normalized for metals. Results of these analyses indicated that concentrations in sediment dry-weight normalized SQGs were as predictive of sediment toxicity in the WBGCR compared to concentrations in sediment normalized to TOC or SEM-AVS (MacDonald et al. 2005).

Comment 19: Page A-1, section 1.1.1 Identification of Chemicals of Concern has the same deficiencies as discussed in the comments on the main body of this report, in that it is assumed that all of the potentially hazardous contaminants in the sediments for human health or aquatic and terrestrial life have been measured and their concentrations are known.

Response: *A major effort has been expended by the GCRRF Council to identify COCs. This effort was done in a public forum and input from the Sanitary District of Hammond was solicited but not received. The GCRRF Council believes that an adequate effort to identify and measure COCs has been made and the bulk of the potentially hazardous contaminants in the sediments for human health or aquatic and terrestrial life have been measured and their concentrations are known within the error ranges identified in the characterization reports.*

Comment 20: Page A-2, first sentence states,

“The primary criterion to be used for the screening of chemicals as potential COPCs is a comparison of maximum detected concentrations to a toxicity-based concentration screen.”

This approach is not technically valid, since, as discussed above, the so-called “toxicity-based concentration screens” are based on co-occurrence and not on cause and effect. Therefore, erroneous conclusions can readily be developed using this approach. The use of PRG values as a screen can lead to gross overestimates of hazard, because of the fact that substantial parts of the contaminants that are being analyzed for are in nontoxic, non-available forms.

Response: *The methodologies proposed for the BHHRA follow the guidance provided by the EPA Superfund Guidance documents and are routinely used to assess risks to human health.*

Comment 21: Beginning on page A-3, the various constituents that have been identified as being of concern to human health are listed for each of the reaches of the WBGCR. A number of these constituents would not be expected to be toxic or adverse to humans.

Response: *The commenter does not identify specific constituents that they state would not be expected to be toxic or adverse to humans. Without a specific list of constituents, we cannot comment on their statements. However, the constituents listed in Appendix A are based on a preliminary screening methodology used by EPA Superfund program. This list of COPCs will be further evaluated in the baseline human health risk assessment.*

Comment 22: Page B-1 begins a discussion of the ecological risk-based approach for establishing preliminary remediation goals. Since this approach is based on total concentrations of constituents, irrespective of whether they are toxic/available, and so-called sediment quality guidelines (i.e., PEC values), it is not technically valid.

Response: *See response to Comments 10 and 11. We continue to disagree with the commenter about the validity of the approach, specifically as it applies to the development of restoration alternatives for the WBGCR. Importantly, the PRGs that have been recommended for the WBGCR have been shown to be reliable predictors of the presence and absence of sediment toxicity (MacDonald et al. 2005).*

Comment 23: Page B-2, paragraph 1.2.2 mentions the use of PEC quotients. This approach is no more valid than the individual PEC values. The so-called quotient approach has no technical validity for identifying specific constituents responsible for ecological effects. Without this identification and an understanding of the current sources, the process of restoration of the WBGCR sediments to eliminate risk can readily be erroneously conducted.

Basically, the approaches outlined in these appendices suffer from the same fundamental flaw as discussed above in the discussions about the main body of the report.

Response: *See response to Comment 10.*

Comment 24: Overall Assessment

The Preliminary Problem Formulation is significantly deficient in serving as an appropriate basis for an NRDA restoration effort for pollutants in the WBGCR sediments. The failure to properly evaluate the impacts of current sources of pollutants that will continue to be discharged to the WBGCR after restoration is a significant deficiency in the PPF that must be corrected if a technically valid, cost-effective, reliable restoration program is to be undertaken.

The approach that has been used to define constituents of concern is at best naïve, in that it is based on technically invalid approaches for assessing chemicals that cause aquatic life toxicity in sediments.

Overall, the PPF needs to be redeveloped, in which the issues discussed herein are properly addressed. Basically, the ecological risk assessment approach that is presented herein needs to be discarded and redone by individuals who understand aquatic chemistry, aquatic biology, toxicology and water quality evaluation.

Response: *The approach adopted represents that approved by all Grand Calumet River Restoration Fund Council Agencies (please refer to introduction to the document for a complete listing of these Agencies) and is adopted to comply with the Court-Ordered settlement of Clean Water Act and Natural Resource Damages in the West Branch Grand Calumet River. This approach has been adopted to address contaminated sediments and natural resource injuries associated with those contaminated sediments. The commenter assumes throughout the comments that the approach proposed herein is solely that of the US Fish and Wildlife Service. This is simply an incorrect assumption on the part of the commenter.*

The PEC approach is not technically invalid. The approach has been extensively validated with over 2000 sediment samples from across North America. Specifically, a weight-of-evidence approach has been used to establish the relationship between sediment chemistry, sediment toxicity with sensitive organisms, or with benthic community assessments. Importantly in both laboratory toxicity tests and in benthic community studies, an incremental increase in effects has frequently been observed with an incremental increase in contamination as defined by the PECs (Ingersoll et al. 2005, Word et al., 2005, Wenning et al. 2005). Importantly, direct measurement of toxicity in laboratory sediment toxicity tests or in benthic community assessments in the field confirm that PECs can be used in the WBGCR to determine if an individual sample with moderate contamination is toxic or nontoxic. Importantly, Wenning et al. (2005) recommend this weight-of-evidence approach integrating measures of sediment chemistry, sediment toxicity, and benthic community impacts in the evaluation of SQGs. This is what has specifically been done to establish the PRGs for the WBGCR (Ingersoll et al. 1996, 2001, 2002; MacDonald et al. 2000, 2002a,b, 2005; USEPA 1996, 2000). Moreover, results of these validation studies across North America and specifically for the WBGCR have been extensively published in the peer-reviewed scientific literature. The commenter advocates use of toxicity identification evaluation (TIEs) procedures. Unfortunately, no standard methods have been published on for the use of TIEs in the assessment of sediment toxicity. Only a limited number of TIEs have been attempted with sediment with acute tests (e.g., 2- to 10-day toxicity tests in pore water) rather than with chronic tests. Importantly, TIE methods lack the specificity needed to identify specific chemicals of concern (Word et al. 2005). Specifically, TIEs that have been attempted with sediment have not been proven to provide sufficient cause and effect relationships between sediment toxicity and the individual chemicals of concern in sediment (Ingersoll et al. 1997). Finally, the opinions expressed by the commenter lack supporting data and lack supporting publications in the peer-reviewed scientific literature.

References

- ASTM (American Society for Testing and Materials). 2005. E 1706-05. Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates. ASTM 2005 Annual Book of Standards Volume 11.05. West Conshohocken, Pennsylvania.
- Barrick R, Becker S, Brown L, Beller H, Pastorok, R. 1988. Sediment quality values refinement: 1988 Update and Evaluation of Puget Sound AET, Vol. I. PTI Contract C717-01, PTI Environmental Services, Bellevue, WA.
- Crane, J.L., D.D. MacDonald, C.G. Ingersoll, D.E. Smorong, R.A. Lindscoog, C.G. Severn, T.A. Berger, and L.J. Field. 2000. Development of a framework for evaluating numerical sediment quality targets and sediment contamination in the St. Louis River Area of Concern. U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL. EPA-905-R-00-008.
- Fairey, R., E.R. Long, C.A. Roberts, B.S. Anderson, B.M. Phillips, J.W. Hunt, H.R. Puckett, and C.J. Wilson. 2001. An evaluation of methods for calculating mean sediment quality guideline quotients as indicators of contamination and acute toxicity to amphipods by chemical mixtures. *Environ. Toxicol. Chem.* 20:2276-2286.
- Ingersoll CG, Bay SM, Crane JL, Field LJ, Gries TH, Hyland JL, Long ER, MacDonald DD, O'Connor TP. 2005. Ability of sediment quality guidelines to estimate effects of sediment-associated contaminants in laboratory toxicity tests or in benthic community assessments. In: Wenning RJ, Batley G, Ingersoll CG, Moore DW, editors. Use of sediment quality guidelines and related tools for the assessment of contaminated sediments. Pensacola FL: SETAC Press, p. 497-556.
- Ingersoll CG, Dillon T, Biddinger RG, editors. 1997. Ecological risk assessment of contaminated sediments. Pensacola FL: SETAC Press.
- Ingersoll CG, Haverland PS, Brunson EL, Canfield TJ, Dwyer FJ, Henke CE, Kemble NE, Mount DR, Fox RG. 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyaella azteca* and the midge *Chironomus riparius*. *J Great Lakes Res* 22:602-623.
- Ingersoll CG, MacDonald DD, Brumbaugh WG, Johnson BT, Kemble NE, Kunz JL, May TW, Wang N, Smith JR, Sparks DW, Ireland SD. 2002. Toxicity assessment of sediments from the Grand Calumet River and Indiana Harbor Canal in northwestern Indiana. *Arch Environ Contam Toxicol* 43:153-167.
- Ingersoll CG, MacDonald DD, Wang N, Crane JL, Field LJ, Haverland PS, Kemble NE,

- Lindskoog RA, Severn CG, Smorong DE. 2001. Predictions of sediment toxicity using consensus-based freshwater sediment quality guidelines. *Arch Environ Contam Toxicol* 41:8-21.
- Ingersoll CG, MacDonald DD. 1999. United States v. Sanitary District of Hammond: Rebuttal of opinions provided in the reports prepared by Dr. JE Alleman and Dr. RE Roper. Report prepared for the Environmental Enforcement Section, Environment and Natural Resources Division, U.S. Department of Justice, Washington, DC, April 1999.
- Long ER and MacDonald DD. 1998. Recommended uses of empirically-derived sediment quality guidelines for marine and estuarine ecosystems. *Human Ecolog Risk Assess* 4:1019-1039.
- Long ER, MacDonald DD, Cubbage JC, Ingersoll CG. 1998. Predicting the toxicity of sediment-associated trace metals with simultaneously extracted trace metal: acid volatile sulfide concentrations and dry weight-normalized concentrations: A critical comparison. *Environ Toxicol Chem* 17:972-974.
- Long ER, MacDonald DD, Smith SL, Calder FD. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management* 19:81-97.
- MacDonald, DD and Ingersoll, CG. 2004. An assessment of sediment injury in the Calcasieu Estuary, Louisiana. Volume I. Draft report. In association with Industrial Economics Inc. Cambridge, Massachusetts. Prepared for Damage Assessment Center. National Oceanic and Atmospheric Administration. Seattle, Washington.
- MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000a. Development and evaluation of consensusbased sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol.* 39:20- 31.
- MacDonald, D.D., L.M. Dipinto, J. Field, C.G. Ingersoll, and E.R. Long. 2000b. Development and evaluation of consensus-based sediment effect concentrations for polychlorinated biphenyls. *Environ. Toxicol. Chem.* 19:1403-1413.
- MacDonald DD, Ingersoll CG, Smorong DE, Lindskoog RA, Sparks DW, Smith JR, Simon TP, Hanacek M. 2002a. Assessment of injury to fish and wildlife resources in the Grand Calumet River and Indiana Harbor Area of Concern, USA. *Arch Environ Contam Toxicol* 43:130-140.
- MacDonald DD, Ingersoll CG, Smorong DE, Lindskoog RA, Sparks DW, Smith JR, Simon TP, Hanacek MA. 2002b. Assessment of injury to sediments and sediment-dwelling organisms in the Grand Calumet River and Indiana Harbor Area of Concern, USA. *Arch*

Environ Contam Toxicol 43:141-155.

- MacDonald, DD, C.G. Ingersoll , D.E. Smorong , L. Fisher , C. Huntington, and G. Braun. 2005. DRAFT Development and Evaluation of Risk-Based Preliminary Remediation Goals for Selected Sediment-Associated Contaminants of Concern in the West Branch of the Grand Calumet River. Prepared for US Fish and Wildlife Service by MacDonald Environmental Sciences, Ltd and US Geological Survey in Association with Tetra Tech FW, Inc. Draft June 2005.
- Peddicord, R.K, C.R. Lee, and R.M Engler. 1998. Use of sediment quality Guidelines (SQGs) in dredged material management. Dredge Research Technical Note EEDP-04-29. Long-Term Effects of Dredging Operations Program. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Persaud, D.R., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediments in Ontario. Standards Development Branch. Ontario Ministry of Environment and Energy. Toronto, Canada.
- Swartz, R.C. 1999. Consensus sediment quality guidelines for polycyclic aromatic hydrocarbon mixtures. *Environ. Toxicol. Chem.* 18:780-787.
- USEPA. 1992. Sediment classification methods compendium. Office of Water. EPA 823-R-92-006.
- USEPA 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyaella azteca* and the midge *Chironomus riparius*. National Biological Service final report for the USEPA GLNPO assessment and remediation of contaminated sediments project. EPA 905/R-96/008, Chicago, IL.
- USEPA. 2000. Prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines. EPA 905/R-00/007, Chicago, IL.
- Wenning RJ, Batley G, Ingersoll CG, Moore DW, editors. 2005. Use of sediment quality guidelines and related tools for the assessment of contaminated sediments. Pensacola FL: SETAC Press, 783 p.
- Word JQ, Albrecht BB, Anghera ML, Baudo R, Bay SM, Di Toro DM, Hyland JL, Ingersoll CG, Landrum PF, Long ER, Meador JP, Moore DW, O'Connor TP, Shine JP. 2005. Predictive ability of sediment quality guidelines. In: Wenning RJ, Batley G, Ingersoll CG, Moore DW, editors. Use of sediment quality guidelines and related tools for the assessment of contaminated sediments. Pensacola FL: SETAC Press, p. 121-161.